Morocco

Environmental, Social and Economic Issues of the 21st Century

Ngô Trọng Danh
Editor

AFRICAN POLITICAL, ECONOMIC, AND SECURITY ISSUES

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MOROCCO

ENVIRONMENTAL, SOCIAL AND ECONOMIC ISSUES OF THE 21ST CENTURY

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MOROCCO

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NGÔ TRỌNG DANH
EDITOR

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PREFACE

Located in the North Western fringes of Africa, Morocco stretches from North to South on approximately 3000 kilometers of Atlantic coasts. It is a very diverse country, encompassing several landscapes, such as high mountains (e.g., the Atlas and the Rif) and various plains and oases. Chapter One addresses key features of Morocco's plant diversity, the originality and importance of this national plant heritage for the present and the future nationally and internationally in the light of growing threats and global environmental and political changes. The purpose of Chapter Two is to palliate to this issue by developing a spectrometric approach for monitoring soils and waters; an approach which is effective, fast, easy to implement and reliable. Chapter Three reports on the emerging challenges facing the Moroccan agricultural sector. Chapter Four reports on the many efforts that have been made in recent decades in Morocco in the priority areas of sustainable development and the environment to promote a green and inclusive economy while taking into account the threefold aim of respecting the environment, fighting against poverty and sustaining the economic activity. Chapter Five will: 1) focus on sustainable development strategy adopted in the kingdom; 2) concentrate on the economic, social and health system components as health determinants, and finally discus relationships between health- sustainable development and climate change. Chapter Six will clarify the theoretical concepts underlying the notion of

the emergency and the time pressure and will appeal the exploration through a qualitative approach and use individual interviews with Moroccan SMEs' managers in the empirical study in order to answer the question.

Chapter 1 - Because of its geographic location, at the intersection between the Atlantic Ocean in the west, the Mediterranean Sea in the North, the Sahara desert in the South and East, and the Atlas Mountains inland, Morocco provides habitats for an original and rich plant diversity. It took more than a century of floristic explorations and field investigations for this diversity to unfold. The 20th century was the time for developing a national herbarium for Moroccan flora at the "Institut Scientifique" in Rabat. The achieved output was the identification of about 7000 taxa. The vascular flora of Morocco, compiled in three volumes, counts 3913 species and 872 additional subspecies belonging to 155 families and 981 genera. The originality of this flora lies in the presence of 14 national endemic genera and 920 taxa (640 species and 280 subspecies). Even though, the Country's official concern with biodiversity conservation goes back to the 1930's of the past century, the 21st century has witnessed strong commitments to implementing *in situ* and *ex situ* conservation strategies. During the last 20 years, Morocco has established a variety of protected areas, over 160 sites of biological and ecological interest (SIBE), 11 national parks, and 19 important plant areas (IPA). The creation of the gene bank at Settat in 2002 provided the needed facility for *ex situ* conservation of the Country's plant genetic resources for food and agriculture. Currently, the gene bank holds 54,000 accessions representing 126 genera and 337 species. This chapter addresses key features of Morocco's plant diversity, the originality and importance of this national plant heritage for the present and the future nationally and internationally in the light of growing threats and global environmental and political changes. It highlights the good opportunities offered by the existing plant diversity in terms of actual and potential uses of plants, particularly endemic plants that exist nowhere else except in Morocco. The chapter also pinpoints the challenges faced in securing effective conservation and sustainable use of national plant diversity for the future generations at both

plant species and ecosystems levels. Solid scientific research and monitoring are essential for effectively conserving and sustainably exploiting Morocco's plant heritage.

Chapter 2 - The promotion of the agricultural production constitutes a main challenge for Morocco. This goal often results in an increased use of pesticides and fertilizers compromising soils and waters. Moreover, in addition to large stocks of pesticides, the invasion by locusts from southern countries requiring massive use of insecticides remains a potential threat for Morocco. Consequently, a continuous monitoring of the different environmental compartments (soil, water, and air) is increasingly needed for all the Moroccan territory

Owing to hundreds of soil and water samples to control, it is important to develop simple and inexpensive methods to assess pollution levels by pesticides in agricultural soils and neighboring waters. The sophisticated chromatographic methods, in spite of their high accuracy, are very expensive and hardly accessible; they can be reserved for laboratory accurate analyses and statutory inspections.

The purpose of this research is to palliate to this issue by developing a spectrometric approach for monitoring soils and waters; an approach which is effective, fast, easy to implement and reliable. In this sense, fluorescence spectroscopy presents a high potential owing to its high sensitivity, ease and rapidity. Total excitation-emission (TEEMs) and total synchronous fluorescence (TSFMs) mappings make it possible to detect remains of fluorescent pesticides in soils or waters. The present investigation aims at the creation/extension of a total excitation-emission and total synchronous fluorescence mapping database to fingerprint those fluorescent pesticides in large use in Morocco. These fluorimetric fingerprints must allow the direct identification of any targeted fluorescent pesticide persisting in soil or water.

After a large survey among farmers and agricultural product distributors, to target the best-selling and most used pesticides in different Moroccan regions, one hundred and five (105) pesticides have been fingerprinted. Applicability tests were carried out on the basis of field pre-surveys information and total fluorescence results.

In the present work, the maps and synchronous spectra of a set of 57 commercial pesticides are reported. Moreover, four examples of TEEMs/TSFMs fingerprinting applications to recognize pesticide remains in soil samples are shown. The agricultural plantations monitored are located in the great agricultural region Doukkala at the western Atlantic side of Morocco. The catalogue has been enriched by a PCA-based statistical study to constitute groups of pesticides with similar spectrometric fingerprints. The emitting similarity inside pesticide groups, despite different active principles, was explained by similarity of formulation products.

The implemented spectrofluorimetric approach is satisfying and seems suitable, at least, as a warning method in case of massive contamination of soils or waters.

Chapter 3 - The Moroccan agricultural sector is facing emerging challenges. First, the country is characterized by a significant water stress, as the volume of renewable water *per capita* does not exceed 750cubic meters per year. In addition, climate change scenarios predict a decrease by 10 to 15% of average rainfall and a rise of 2°C in temperatures over the next decades. As a consequence, water scarcity will be exacerbated. Second, the current national agricultural strategy, namely the 'Green Morocco Plan', aims to increase the overall production of the agricultural sector. To do so, public authorities encourage the adoption of drip irrigation coupled with financial support for drilling boreholes and for pumping equipment, e.g., to irrigate fruit trees and vegetables. As a consequence, in many areas of the country, groundwater depletion is of growing concern. Third, domestic markets have become saturated and fruit prices have plummeted, particularly citrus, hindering the original hypothesis of improved economic water productivity by horticultural crops. Moreover, the current agricultural strategy has neglected rain-fed staple crops, such as cereals and pulses, and farmers growing these crops receive limited support. Fourth, the whole economic growth of the country appears to remain highly vulnerable to the annual rainfall variability. Because of demographic growth, the country has become a net importer of food and feed, e.g., soft wheat, edible oils, dairy products (butter and

cheese), maize, and soya meal, and this may be harmful for its food security. Fifth, Morocco remains a rural country, since 40% of its inhabitants are still considered as employed in the agricultural sector. This is already generating increased tensions on agricultural land. In particular, the numerous land tenure statuses often impede investments in agricultural activities that would be made on the long term. Despite these challenges, the growing domestic demand for food products constitutes a strong opportunity for improved livelihoods for the people employed in this sector. As a consequence, young farmers engage in innovative learning processes in order to achieve higher crops and livestock yields, as well as improved farms' profitability. Altogether, these elements suggest that the Moroccan agricultural sector will need to actively face new challenges, especially in relation to water management in a context of climate change, sound extension services and improved labor remuneration, as well as the satisfaction of growing food demand. These challenges may require new governance standards, which impose not only to produce higher quantities of food products but also of better quality and to do so in an environmentally sustainable way. Priority should be hence set to capacity-building of human resources and to promoting rain-fed systems that integrate crops and livestock rather than focusing only on support to heavy investments in irrigation, with limited attention to market and environmental issues.

Chapter 4 - Many efforts have been made in recent decades in Morocco in the priority areas of sustainable development and the environment to promote a green and inclusive economy while taking into account the threefold aim of respecting the environment, fighting against poverty and sustaining the economic activity. However, the country remains compelled for a better mobilization against the sources of environmental degradation. Several kinds of limitations hinder this transition today and a number of challenges still need to be addressed to begin the transition to the green economy and, more broadly, to sustainable development.

Chapter 5 - Africa, a continent at the dawn of its development, is therefore the least polluting one. The economic and social well-being of

present and future African populations is heavily dependent on good governance and regionalization based on efficiency to meet specific needs and also on mutual assistance. On the other hand, good environmental policy will ensures equitable management of resources, in particular water, forestry, fisheries and agriculture. All African regions, including Morocco have to cope with climate imbalances, population explosion, globalization, exploitation and the management of their resources. The current pattern of consumption threatens people with vulnerability due to its impact on famines, epidemics, damage to biodiversity and natural disasters. Climate change has impact on the development issue and prompt response to support climate change mitigation and adaptation of the African continent, in particular, Morocco. Efforts to address climate change issues date back to the Rio Earth conference in 1992 yet significant deficits still remain. Climate change has had substantial effects on sustainable development. Although the African continent is the least contributor to greenhouse gases, it is the most vulnerable to the adverse impacts of global climatic change due to inadequate adaptive capacity. This vulnerability represents therefore a real obstacle that limits and blocks any development through major consequences, such as high water stress, socio-ecological and economic problems, food and water security, uncontrolled migration, peace and health. Despite de development of a strategy of sustainable development, Morocco remained one of the most affected African countries, in particular on health issues. If in the past, the health of individuals was considered just as an indicator of physical and mental well being. Today, in the context of sustainable development, health must be seen as the result of interactions between the biophysical, social and economic environment. If health disparities are blatant, the country development is neither stable nor safe, but health alone is not enough to make the world just. Against this background, Morocco must have the highest interest in a functional governance framework which has the capability to improve its strategy of sustainable development.

In this study, the authors will: 1) focus on sustainable development strategy adopted in the kingdom; 2) concentrate on the economic, social and health system components as health determinants, and finally discus

relationships between health- sustainable development and climate change. The authors dress recommendations aimed to build an open, productive and healthy society.

Chapter 6 - The world is experiencing today a period of deep change whose pace is on growing. It lives in a period of instability heralding the advent of a society marked by the uncertainty and the turbulence. Currently, the consideration of environment and the necessity to react quickly are required. The importance of those elements is linked to the subjective perception. This latter is even more palpable through the focusing of the leaders on two aspects of the environment namely and uncertainty.

Managing in these conditions becomes a constant worry within companies. Those latter are obliged to do the maximum in record time to stay ahead of competitors. So, managing in emergency becomes a new rule not an exception any more.

The rise of the emergency concept reflects a mutation that took place when the speed correlated to the conquest of space (new markets), has integrated the time. This emergency has invaded the organizations. It is consistent with the context of globalization and increased competition that need quick responses.

The emergency to act touches almost every aspect of business: its nature, its location, the price, the distribution system, the personnel policies… Hence, it is important to learn about the various components of the emergency in which the business has to operate in order to run a business unit successfully.

Moroccan SMEs, representing more than 80% of Moroccan firms, live under multiple constraints and transformations. The interaction between these companies and their environment leads to inevitable pressures making them unimmunized. These SMEs are influenced by the contingent factors and competitive pressures that condition their performance. They are faced to the economic globalization and the need to integrate the emergency to all their actions and to conserve their market place.

These companies seem caught in a paradoxical movement: they would like to think under the sign of the project and anticipation, in the same time

they are forced to manage the emergency. They are concerned by the obligation to stay alive with all the environment constraints. Then, how they can face with the pressure of time and integrating the emergency into their management?

While little research has been devoted to it, the authors will clarify the theoretical concepts underlying the notion of the emergency and the time pressure. The authors will appeal the exploration through a qualitative approach and use individual interviews with Moroccan SMEs' managers in the empirical study in order to answer the question.

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Chapter 1

CONSERVING PLANT DIVERSITY: AN OPPORTUNITY FOR THE 21ST CENTURY FOR MOROCCO

Fatima Nassif [*] ***and Abbes Tanji***
Ex-researchers at the National Institute for Agronomic Research, CRRA-Settat, Morocco

ABSTRACT

Because of its geographic location, at the intersection between the Atlantic Ocean in the west, the Mediterranean Sea in the North, the Sahara desert in the South and East, and the Atlas Mountains inland, Morocco provides habitats for an original and rich plant diversity. It took more than a century of floristic explorations and field investigations for this diversity to unfold. The 20th century was the time for developing a national herbarium for Moroccan flora at the "Institut Scientifique" in Rabat. The achieved output was the identification of about 7000 taxa. The vascular flora of Morocco, compiled in three volumes, counts 3913 species and 872 additional subspecies belonging to 155 families and 981 genera. The originality of this flora lies in the presence of 14 national

[*] Corresponding Author E-mail: fatima.nassif@gmail.com.

endemic genera and 920 taxa (640 species and 280 subspecies). Even though, the Country's official concern with biodiversity conservation goes back to the 1930's of the past century, the 21st century has witnessed strong commitments to implementing *in situ* and *ex situ* conservation strategies. During the last 20 years, Morocco has established a variety of protected areas, over 160 sites of biological and ecological interest (SIBE), 11 national parks, and 19 important plant areas (IPA). The creation of the gene bank at Settat in 2002 provided the needed facility for *ex situ* conservation of the Country's plant genetic resources for food and agriculture. Currently, the gene bank holds 54,000 accessions representing 126 genera and 337 species. This chapter addresses key features of Morocco's plant diversity, the originality and importance of this national plant heritage for the present and the future nationally and internationally in the light of growing threats and global environmental and political changes. It highlights the good opportunities offered by the existing plant diversity in terms of actual and potential uses of plants, particularly endemic plants that exist nowhere else except in Morocco. The chapter also pinpoints the challenges faced in securing effective conservation and sustainable use of national plant diversity for the future generations at both plant species and ecosystems levels. Solid scientific research and monitoring are essential for effectively conserving and sustainably exploiting Morocco's plant heritage.

Keywords: SIBE, Important Plant Area (IPA), plant diversity

INTRODUCTION

The geographical location between the vast desert, the long coast of the Atlantic Ocean and the Mediterranean Sea has enabled Morocco to possess highly diverse ecosystems with a tremendously rich plant diversity. However, this diversity is so fragile that it can easily be destroyed if not adequately preserved and strongly protected. In 1996, Morocco has established the national strategy or master plan for protected areas (Plan Directeur des Aires Protégées du Maroc -PDAPM). The objective of the plan was the establishment of protected areas representative of the 40 natural ecosystems of the Country using both ecological and socio-economic considerations (Aghnaj et al., 2012). This resulted in the creation of a nationwide ecological network of 163 sites of biological and ecological interest (SIBE in French is the acronym commonly used to refer to these sites) representative of the bio-

ecological zones, remarkable ecosystems and a high concentration of endemic, rare or threatened plant and/or animal species. Over the years, some of these sites were developed into national parks, other sites acquired the Ramsar status while another group currently classified as important plant areas (IPA) using criteria and categories of the International Union for Conservation of Nature (IUCN). The ultimate objective of these measures is the conservation of this diversity for the years to come and allowing the future generations to benefit from it as did their parents and ancestors.

This chapter is organized into four parts starting with a brief highlight of key phases of the unfolding process of plant diversity in Morocco. Part I presents a detailed overview of Morocco's diversity from the ecosystem level to the species level with emphasis on vascular flora (originality, endemism, rarity, threatened plants, etc.). Part II illustrates outcomes of adopted *in situ* and *ex situ* conservation approaches to preserving national plant diversity (160 SIBEs, 11 National Parks, 19 IPAs, 4 Biosphere Reserves, the National Herbarium of the Institut Scientifique, and the National Gene Bank in Settat). Part III discusses the actual and potential opportunities offered by plants in Morocco with emphasis on medicinal, food, ornamental plants and crop wild relatives. Part IV addresses three main challenges, among many others, that need urgent actions exemplified in the development challenge, research, conservation and protection.

Unfolding Morocco's Plant Diversity

Building Moroccan flora has not been an easy task, nor has it been done overnight. It took more than a century of intensive work and tremendous efforts for Morocco's plant diversity to unfold. The 20th century has been the time for challenging floristic explorations and expeditions in remoted mountains and desert areas. The literature is rich of examples of botanic notes and accounts, lists and florulas of localities and areas indicated at the time under appellations of French Morocco, Spanish Morocco, Spanish Sahara, Occidental Sahara, and Desert Areas.

In the first volume of the 'Catalogue des Plantes du Maroc', published in 1931, Jahandiez & Maire (1931-1934) reported the list of published

works on Moroccan flora over the period between 1675 and 1931. Only 59 of the 350 elements contained in the list were published before 1900. Within the ten-year period separating the first volume and the supplement of the catalog by Emberger & Maire (1941), the list was extended by more than 240 titles (reports of missions, field trips, annotated lists of plants, accounts of floristic explorations, bibliographic notes, studies, formulas of particular localities, etc.). This means that the first half of the 20th century was a period of intensive work on Morocco's flora.

Morocco's plant diversity has attracted enthusiasts and plant passionate explorers from all over the world and there are learning lessons from those contributors and the process of building knowledge and understanding Morocco's flora. Moroccan students and young researchers must keep in mind that Maire published the results of his explorations of Morocco's High and Middle Atlas Mountains in 1924 after having climbed these mountains in 1921 (Maire, 1924) and that he made twenty-seven trips to Morocco between 1931 and 1936 (http://www.encyclopedia.com). In his persistent and intensive efforts to uncover Morocco's plant mysteries, Maire produced detailed descriptions, analyses and explorations. This includes, among many outputs, the Mediterranean character of the Souss, the coastal flora, the floral constituents in the Rif, the Zaian, Tichoukt, the summits of the High Atlas, the Anti-Atlas, the high Dra River, the Tafilalet, and the Plateau of the Lakes District (http://www.encyclopedia.com).

One of the early works on Morocco's Saharan flora, then named Western Sahara is Maire's contributions and notes (Maire, 1925, 1935, and 1936). The most outstanding contribution is reported in fascicule 6 where the florula of Guelta Zemmour is described with vernacular names collected from the Rguibat and Maure and adequately transcribed in Arabic characters (Maire, 1935). In their field visit to the Guelta Zemmour area in July 2016, the authors met with several local inhabitants to ascertain the current relevance of reported vernaculars and collect new ones (Nassif and Tanji, unpublished data). The contribution by Maire is only one example among many others showing the hard work, the perseverance and the rigor required for studying plants and building floras.

In the preface of the first volume of the ‘Flore Pratique du Maroc’ (FPM) published in 1999, Quézel wrote, “The tool that is now placed in our hands is precisely fulfilling an increasingly pressing demand, at a time when knowledge of biodiversity, in particular vegetation, is a basic imperative in all interventions on the natural environment. It will greatly facilitate a coherent and universally accessible policy in conservation biology. Finally, it will enable us to understand clearly and easily the incomparable botanic capital represented by Moroccan flora and to clarify the risks faced by a significant number of its representatives" (Fennane et al., 1999).

In the preface of the second volume of the ‘Flore Pratique du Maroc’ published in 2007, Mathez stated, “Sixteen years were needed to give birth to the first volume of the FPM, then seven more for the second. We hope that the team's determination will not diminish despite the decline in the number of researchers in the permanent team, some of whom are reaching retirement age, and that the resources continue to be allocated to them so that the publication of the third and the last volume envisaged to come soon to conclude years of stubborn efforts. The renewed global interest in biodiversity, its knowledge and its sustainable exploitation augurs well: Morocco, “hot spot” recognized, needs more than ever a Flore” (Fennane et al., 2007).

In the preface of the third volume of the ‘Flore Pratique du Maroc’ published in 2014, Greuter stated, “Morocco can be proud of this work produced by national researchers of the Institut Scientifique. They form a human capital and a research institution of inestimable value for the Country, and well beyond. The Flora opens new horizons to the knowledge, development and conservation of the Moroccan botanic heritage, a resource of inestimable material and spiritual value. A value that Morocco has pledged to safeguard by signing the Convention on Biological Diversity (CBD) and its related agreements. However, it would be impossible to protect this heritage effectively without a solid knowledge of the organisms themselves” (Fennane et al., 2014).

Finally, it is worth reading and understanding the painful yet gratifying historical journey of building Morocco’s flora as reflected in some excerpts

from the foreword by Fennane of the third volume of the Flore Pratique du Maroc (Fennane et al., 2014). Fennane wrote "The idea of writing a flora of Moroccan vascular plants goes back to the 1940s (of the 20th century), just after the publication of the 'Catalogue des Plantes du Maroc' (Jahandiez & Maire, 1931-34; Emberger & Maire, 1941). Several attempts have been made since the 1950s, but they remained unsuccessful or incomplete. The project has led to debates, aroused quarrels and affected the mood of botanists, users and managers of the national green heritage. The preface to this volume and those of the previous two give a foretaste of this atmosphere that lasted for decades. Today's result is the culmination of work that began in October 1982. At that time, the 'Flore Pratique du Maroc' project was officially launched with a five-year timetable for completion. Nobody was dupe and everybody knew that it would not be achieved. Many people were even skeptical as to the continuation of the project and the specter of failures of the preceding attempts always hovered, and strongly upon all minds. The preparation of the three volumes finally required 32 years. The 'Flore Pratique du Maroc' is neither perfect nor complete. In all modesty, it is a step facilitating ongoing research on the flora of Morocco and paving the way for further investigations. With this page turned, the satisfaction of the authors is lessened by the worrying state of our floristic research. The first generation of national researchers is ready for retirement, with no relief at least in the short term. The need is urgent for our young people to rekindle the torch of botany in Morocco. Let this "event" be a stimulus to blow again a good air of optimism" (Fennane et al., 2014).

Other key publications on Morocco's flora include the 'Catalogue des Plantes Vasculaires Rares, Menacées ou Endémiques du Maroc (Fennane & Ibn Tattou, 1998) and the two volumes on Morocco's vascular flora (Fennane & Ibn Tattou, 2005; Ibn Tattou & Fennane, 2008). The knowledge of Moroccan flora was enriched by the publication of two volumes on vascular flora of the North of Morocco (Valdés et al., 2002). With the exception of the latter, all the other publications were made by the same national team of the Institut Scientifique in Rabat.

PART I: PLANT DIVERSITY IN MOROCCO - AN OVERVIEW

Morocco a Hot Spot in the Mediterranean Basin

The literature is unequivocally unanimous regarding the originality of Moroccan flora within the Mediterranean Basin and North Africa. The importance of national endemics is often the first element evoked. The second element is the extent of rare and very rare taxa contained in the flora. The third element is the diversity in actual and potential plant uses.

The Mediterranean Basin is a center for diversity (Médail & Quézel, 1997, 1999; Heywood, 1999). As noted by Médail & Quézel (1997, 1999), the Mediterranean Basin covers only 2% of the world surface area and contains 20% of the total world floristic range. The estimated total number of Mediterranean plants varies between 45,000 and 60,000 species (Médail and Quézel, 1997, 1999). As explained by Heywood (1999), the importance of the Mediterranean region derives from 12 considerations. Because of their relevance, several of these considerations are reported in the following:

1. The Mediterranean region is one of the world's major centres of plant diversity containing 11 of the 231 centres selected for their global importance.
2. The region is one of the centres of diversity for crop plants.
3. Many crop relatives occur in the Mediterranean Basin.
4. The region covers some 2.3 million-km^2 representing some 1.6% of the land surface yet contains about 10% of the world's flowering plants.
5. The flora of the Mediterranean region is floristically rich in comparison with adjacent temperate and desert regions.
6. The high degree of local endemism.
7. The high degree of human interference and disturbance of the vegetation, a process that dates back over ten thousand years.
8. The high percentage of annual species in the flora, especially in families such as the *Caryophyllaceae*, *Brassicaceae* (Cruciferae),

Asteraceae (Compositae), and *Apiaceae* (Umbelliferae) (Heywood, 1999).

With more than 7000 taxa (including fern, mosses, fungi, vascular plants) Morocco is certainly a major contributor to the Mediterranean plant diversity (Table 1a). Médail & Quézel (1997) noted the presence of two main centers of biodiversity in the Mediterranean Basin: one in the West including the Iberian Peninsula and Morocco, and one in the East including Turkey and Greece. More specifically, Médail & Quézel (1997) stated that two of the ten red alert areas or 'hotspots' situations in the Mediterranean Basin are located in Morocco. These are the High and Middle Atlas mountains and the Baetic-Rifan complex. The definition of 'hotspot' adopted by Médail & Quézel (1997) is the following: "a hot-spot is a sector with an exceptional concentration of species and a high rate of endemism that is in great danger of destruction. Species richness and endemism are two attributes of biodiversity commonly used in Conservation Biology because they reflect the complexity and uniqueness of ecosystems."

According to Morocco's national strategy and action plan 2016-2020, the Country's diversity is reflected in the diversity of ecosystems (Table 1b), the significant number of species and high endemic rates, and particularity the richness of genetic resources (MDCE, 2014a).

Table 1a. Taxonomic groups of Morocco's plant diversity

Taxonomic group	Number of inventoried species	Number of estimated species
Multicellular algae	500	600
Superior mushrooms	820	1000
Lichens	700	1000
Mosses	350	500
Fern	60	60
Phanerogams	5211	5211
Total	7641	8371

Source: Ministère Délégué Chargé de l'Environnement - MDCE, 2014b.

The 40 Ecosystems of Morocco at the Base of National Diversity

Morocco is endowed with diverse physical environmental features allowing a great diversity of ecosystems, namely forest ecosystems, pre-forest, steppe, pre-steppe, desert, and aquatic ecosystems. In addition, Moroccan ecosystems extend over a range of bioclimatic levels from arid, semi-arid, sub-humid, to humid. Most of these ecosystems are described in Benabid (2000).

Table 1b. Moroccan terrestrial ecosystems

1	*Abies maroccana*	21	*Maerua crassifolia*
2	*Acacia ehrenbergiana*	22	*Olea oleaster*
3	*Acacia gummifera*	23	*Pinus maghrebiana*
4	*Acacia raddiana*	24	*Pinus halepensis*
5	*Adenocarpus anagyrifolius*	25	*Pinus iberica*
6	*Ammophila arenaria*	26	*Pinus nigra mauritanica*
7	*Argania spinosa*	27	*Pinus pinaster*
8	*Artemisia inculta*	28	*Pistacia atlantica*
9	*Balanites aegyptiaca*	29	*Quercus coccifera*
10	*Buxus balearica*	30	*Quercus faginea*
11	*Capparis decidua*	31	*Quercus pyrenaica*
12	*Cedrus atlantica*	32	*Quercus rotundifolia*
13	*Ceratonia silique*	33	*Quercus suber*
14	*Cupressus atlantica*	34	*Retama dasycarpa*
15	*Euphorbia sp.*	35	*Stipa tenacissima*
16	*Fraxinus dimorpha*	36	*Tamarix sp.*
17	*Juniperus phoenicea*	37	*Tetraclinis articulata*
18	*Juniperus thurifera*	38	*Traganum moquinii*
19	*Dayas*	39	*Spiny xerophytes ecosystem*
20	*Halophile ecosystem*	40	*Dunes ecosystem*

Source: Birouk et al., 1995.

Forest Ecosystems: The Founding Blocks of Morocco's Plant Diversity

In Morocco, not only are forest ecosystems important but they represent 75% of the 40 terrestrial ecosystems identified above (Birouk et

al., 1995; Mhirit & Maghnouj, 1997). Forests provide suitable habitats for the development of plants of all kinds. As reported by Taleb (2016), in Morocco, nearly two thirds of the species of the vascular flora occur in forest ecosystems. Steppe formations and wetland habitats share the remaining third. Forest ecosystems are rich in trees, shrubs, as well as herbaceous species, of which a good many plants are endemic and/or of medicinal aromatic interest. Table 2 presents the main forest tree species that organize particular ecosystems with selected statistics on covered area, species richness, and biogeographic distribution.

In Morocco, forest ecosystems are essentially located in mountainous ranges, thus, providing habitats for species richness and endemism. Médail & Quézel (1997) indicated that the High and Middle Atlas mountains, covering an area around 50,000 km^2, are populated by numerous endemics-306 and 237, respectively.

The four major threats to Morocco's forest ecosystems are overgrazing, deforestation, urbanization and climate change (Taleb, 2016). In their report on Morocco's forest ecosystems and climate change, Mhirit & Et-Tobi (2010) suggest that climate change affects forests significantly in terms of forest distribution, health, productivity, and especially, disturbance regimes. However, the authors note that Moroccan forest ecosystems are exceptional, have multiple interests and have demonstrated a great ability to resist climate and human pressure in the past. The impact of climate change on forest ecosystems and the communities that depend on them will depend on a range of positive and negative biophysical and socio-economic effects.

According to the third national communication to UNFCCC, climate change has a definite impact on Moroccan forest ecosystems that play an important role for the Country's economy and for the local populations (MDCE, 2016). In Saharan, arid, and semi-arid bioclimates, this results in a water stress on the vegetation, which will encourage the spread of desertification and, consequently, the progressive movements towards the north, in search of freshness and humidity. In humid and subhumid bioclimates, the trend is towards dry bioclimates and the disappearance of some forest species such as *Abies maroccana* of Talassemtane, *Cedrus*

atlantica in Ketama, and *Juniperus thurifera* of the High Atlas. These trees will be replaced by species more adapted to hydric deficits such as *Tetraclinis articulata*, *Ceratonia siliqua*, *Pinus halepensis*, *Pistacia atlantica* and *Juniperus phoenicea* (MDCE, 2016).

Table 2. Main forest trees

Forest tree species	Area in 2012 (ha) (HCEFLCD, 2014)	Biogeographic units	Species richness (Reference)
Abies maroccana	4,800	Western Rif- near Chefchaoun	200 (Fennane, 1997)
Acacia ehrenbergiana, Acacia gummifera, Acacia raddiana	1,000,000	Saharan regions	-
Argania spinosa	952,200	Semi-arid and arid zones of the South	1 000 (Fennane, 1997)
Cedrus libani subsp. atlantica	128,300	Rif, Middle Atlas, High Atlas Oriental	1000 (Fennane, 1997)
Juniperus sp.	478,500	Middle Atlas, High Atlas	-
Pinus halepensis & Pinus pinaster	104,200	Rif, Middle Atlas, High Atlas	-
Quercus canariensis	15,800	Tanger, Rif, Tazekka, Middle Atlas	-
Quercus rotundifolia	1,345,300	-	-
Quercus suber	293,500	Essentially in the northern western part of the Country	900 (Fennane, 1997)
Tetraclinis articulata	671 100	Mediterranean – southern western regions	600 (Fennane, 1997)
Other forest trees	1,693,000	-	-
Natural forests	5,686,700	-	-
Artificial forests (Planted)	642,300	-	-
Macrochloa tenacissima = Stipa tenacissima	2,999,000	Arid steppes of the Oriental	-

Impacts resulting from the degradation and loss of forest plant tissue would have an impact on biodiversity, forest productivity and the welfare of local populations. The effects of the various forms of degradation and loss affecting forest ecosystems are particularly important in mountainous areas (MDCE, 2016).

Wetlands ecosystems are also important in Morocco. In the Southern side of the Mediterranean, Morocco is the richest in wetlands (dayas, lagoons, lakes, merjas, etc.) (Hammada, 2007). Wetlands are complex and rich ecosystems that provide habitats for a rich biodiversity. According to Hammada (2007), until the 1980's, studies on aquatic vegetation focused on algae and only few studies examined estuarine and temporary palustrine environments. The first wetlands special inventory based on both bibliography and field investigations was published in 2002 (Hammada, et al., 2002). Wetlands are home to a very rich flora and the total number of inventoried taxa amounts to 942 species and subspecies, belonging to 99 families (Hammada, 2007), of which 670 taxa are wetland infused while the remaining 272 are known as terrestrial species, but can periodically colonize wetland areas. Most represented families are *Poaceae*, *Asteraceae*, *Fabaceae*, and *Cyperaceae* (Hammada, 2007). In Morocco, wetlands have experienced and are experiencing strong disturbances in their functioning because of successive droughts, urbanization, and other human activities leading to the loss of habitats and subsequently threatening existing plant diversity. Like the rest of biodiversity rich ecosystems, wetland habitats and species are increasingly threatened.

Moroccan Vascular Flora – Key Statistics

As indicated on Table 1, Moroccan flora (including lichens, fungi, mosses, fern, multicellular algae, and phanerogams) comprises 7641 inventoried taxa while the estimated number rises to about 8371 taxa (MDCE, 2014a). Most importantly, some of the advanced numbers originate from old publications without complete coverage of all Moroccan territory, except in the case of fern and phanerogams. The real number of

Moroccan flora is difficult to obtain in the absence of current and sufficiently dynamic floristic research in concerned areas.

In a recent inventory of Morocco's vascular flora, Fennane & Ibn Tattou (2012) state that the Country hosts 3913 species and additional 872 subspecies, belonging to 155 families and 981 genera. The authors suggest that the increase shown in this inventory at the family level (+20 families) and genus level (+41) in comparison with previous numbers is primarily due to taxonomic revisions and not to new discoveries. The seven large families contain 2100 taxa as indicated in Table 3.

Table 3. The seven richest plant families in Moroccan vascular flora

Plant family	Number of species	Number of subspecies	Rank
Asteraceae	550	126	1
Fabaceae	424	105	2
Poaceae	355	77	3
Brassicaceae	212	66	4
Caryophyllaceae	204	68	5
Lamiaceae	202	60	6
Apiaceae	153	24	7
Total (7 families)	2100	526	-
Other families	1813	346	-
Total	3913	872	-

Source: Fennane and Ibn Tattou, 2012.

National Endemism

Within the Mediterranean Basin, Médail & Quézel (1997) observed that the percentage of endemics is highest in Turkey (31%), then Morocco (21%) and Spain (19%). As also pointed out by these authors, assessment of endemics by country never or rarely includes the endemics of the entire Mediterranean Basin, which clearly underestimates the indicated rate of endemism.

According to Fennane & Ibn Tattou (2012), the number of national endemic amounts to 920 taxa (640 species and 280 subspecies). El Oualidi

et al. (2012) published a checklist of endemics and specimen - types of North Africa including Morocco. As shown on Table 4, *Asteraceae* stands as the richest family in terms of number of national endemics. However, *Lamiaceae* holds the first place in terms of endemic rate. The seven richest families in national endemics comprise more than 400 taxa with an average endemic rate of 23% compared with a national endemic rate of 16% at the species level and 32% at the subspecies level (Fennane & Ibn Tattou, 2012). In addition, Morocco's flora contains 14 endemic genera. Seven of these genera belong to *Brassicaceae* (*Ceratocnemum*, *Crambella*, *Fezia*, *Hemicrambe*, *Roripella*, *Rytidocarpus*, *Trachystoma*), 3 *Asteraceae* (*Aliella*, *Heliocauta*, *Nivellea*), 1 *Amaranthaceae* (*Traganopsis*) 1 *Campanulaceae* (*Feeria*), 1 *Lamicaeae* (*Pitardia*) and 1 *Scrophulariaceae* (*Bartsiella*) (Fennane & Ibn Tattou, 2012).

Table 4. The seven richest families in national endemics and their endemic rates

Plant family	Total number of taxa	Number of national endemics	Endemic rate (%)	Rank according to endemic rate
Lamiaceae	202	80	40	1
Plumbaginaceae	46	13	28	2
Asteraceae	550	131	24	3
Scrophulariaceae	134	29	22	4
Apiaceae	153	30	20	5
Brassicaceae	212	42	20	5
Fabaceae	424	78	18	7
Total	1721	403	23	-

Source: Fennane & Ibn Tattou, 2012.

Rarity

In the absence of recent global assessments regarding the status of plant taxa in Morocco, the work by Fennane & Ibn Tattou (1998) remains the only comprehensive and relatively complete source on rare and threatened plant species. Based on this source, recorded plant species and subspecies are distributed across different categories of rarity. About 59%

of the 2193 rare taxa in Morocco belong to the very rare category (Table 5). Suspected rare and very rare taxa contribute about 20%. About 109 families contain rare taxa with more than half of rare taxa (1250 taxa) found in the following eight families, namely *Asteraceae*, *Fabaceae*, *Poaceae*, *Lamiaceae*, *Caryophyllaceae*, *Brassicaceae*, *Scrophulariaeae*, and *Apiaceae* (Fennane & Ibn Tattou, 1999). On the taxonomic level, more than 60 rare taxa are of doubtful status and deserve further research (Fennane & Ibn Tattou, 1999). The high number of taxa with question marks implies the existence of knowledge gaps on these taxa and the significant scope of the work yet to be done.

Table 5. Botanic importance of rare taxa in Morocco according to rarity categories

Category	Abbrev.	Number of taxa	% of total
Very rare	RR	1288	58.7
Rare	R	463	21.1
Suspected very rare	RR?	372	17.0
Suspected rare	R?	70	3.2
Total		2193	100

Source: Fennane & Ibn Tattou, 1999.

Endemic and Rare Species: The Poorly Known and Most Threatened Plants of Morocco

The double status of endemism and rarity affects more than 1,000 taxa in Morocco (Table 6). This category of plants is of utmost importance. The loss of endemics is harmful not only to Morocco but to international plant diversity. As suggested by Rankou et al., (2013), “the High Atlas, Middle Atlas and the Rif Mountains are the three richest floristic regions for endemic species, but the endemics are not restricted to these floristic regions only. Conservation efforts are therefore necessary in both the Mediterranean and Saharan ecoregions to preserve the biodiversity and

botanical richness of Morocco." Table 7 clearly shows the richness of mountain peaks in endemic-rare taxa.

Table 6. Botanic importance of endemic-rare taxa according to major geographic division in Morocco

Geographic division	Abbrev.	Number of endemic-rare taxa
High Atlas	HA	250
Middle Atlas	MA	166
Rif	R	154
Anti-Atlas	AA	106
Maroc Atlantique Nord	Man	100
Maroc Atlantique Moyen	Mam	90
Maroc Saharien	Ms	57
Plaines et plateaux du Maroc Oriental	Op	34
Littoral de la Méditteranée	LM	31
Monts du Maroc Oriental	OM	16
Atlas Saharien	As	2
Total		1006

Source: Fennane & Ibn Tattou, 2004.

Table 7. Botanic richness of Morocco's mountain summits in endemic-rare taxa (species & subspecies)

Mountain specification	Abbrev.	Number of endemic-rare taxa
High Atlas occidental	HA1	11
High Atlas central	HA2	58
High Atlas/Massif de Mgoun	HA3	49
High Atlas/Massif de Ayachi	HA4	21
High Atlas oriental	HA5	19
Middle Atlas/Tichoukt	MA1	17
Middle Atlas/Bou Iblane & Bou Nacer	MA2	45
Rif	R	13
Anti-Atlas/Kest	AA1	4
Anti-Atlas/Siroua	AA2	5
Anti-Atlas/Saghro	AA3	4
	Total	246

Source: Fennane & Ibn Tattou, 2004.

Lichens in Morocco

The inventory of lichens and lichenicolous fungi of the reference collection of the National herbarium "RAB" of the Scientific Institute - Rabat contains 173 genera and 1087 species, subspecies, varieties and forms. The specimens come from several regions of Morocco and from other countries in Africa, Europe, Asia and America (Ajaj et al., 2007). Four highlights pertaining to the inventory are: a) specimens are old, collected between 1924 and 1996, b) most represented genera are *Lecanora* (85 taxa), *Cladonia* (73 taxa) and *Parmeila* (73 taxa), c) knowledge on Moroccan lichenic flora is still poor, and d) the inventory should be useful for researchers even if it has not been updated (Ajaj et al., 2007).

The fifth national report to the CBD (MDCE, 2014b) suggests that the rarefication of several species and even the disappearance of others are the results of ecosystem malfunctions such as *Cedrus atlantica* ecosystem, *Quercus suber*, *Juniperus thurifera* ecosystem, and the destruction of habitats providing favorable environments for the growth and development of a rich and diversified flora and fauna. With respect to the flora, out of the 7,000 inventoried taxa, one fourth is rare and/or threatened (MDCE, 2014b). Plants in high mountains, which include significant numbers of rare, threatened and endemics are the most affected (MDCE, 2014b).

PART II: CONSERVING PLANT DIVERSITY IN MOROCCO

Heywood (1997a) mentioned the close link between conservation and development as stated in the 1980 World Conservation Strategy. In the Strategy, "conservation is defined as the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations (IUCN, 1980). In the conclusion of his communication on economic aspects of biodiversity conservation, Heywood (1997b) stated, "we must try to preserve the maximum of

biodiversity that the planet harbors, not only for the resources that we have already identified with a direct or indirect value. But also because this biodiversity could contain the means for adapting ourselves to the evolution of our environment to the conditions provoked by man himself."

Main National and International Frameworks (Laws, Strategies, Programs, Etc.) Supporting Plant Conservation

International Framework

With the exception of the International Treaty on Plant Genetic Resources for Food and Agriculture focusing on plants, most international conventions are concerned with biodiversity in its animal and plant components, habitats, use, trade, conservation, protection and other related issues.

In 1975, Morocco ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora. The Bulletin Officiel n° 3553 of December 1980 published the integrality of the Convention with appendices. The Convention, commonly known under its acronym CITES, aims at ensuring that international trade in specimens of wild animals and plants does not threaten their survival. Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it provides varying degrees of protection to more than 35,000 species of animals and plants, whether they are traded as live specimens or dried herbs. CITES adopted a strategic vision 2008-2020 in harmony with the CBD strategic plan and Aichi targets. Although CITES is legally binding on the Parties, it does not take the place of national laws. In other words, countries have to ensure that CITES is implemented based on their national legislation.

The *Convention* on Wetlands, popularly known as the *Ramsar Convention, provides the* framework for national action and international cooperation for the conservation and wise use of wetlands and their

resources. Because of their international importance, Ramsar sites are recognized vital wetland ecosystems for biodiversity and for mankind. The Ramsar convention entered into force in Morocco since October 1980. Currently, the Country has 24 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 272,010 hectares (http://www.ramsar.org/wetland/morocco). Recently, Morocco launched the National Strategy and Action Plan of Wetlands 2015-2024 to honor the Country's international commitments to the Convention on Wetlands (Ramsar), the Convention on Biological Diversity (CBD), and the United Nations Framework Convention on Climate Change (UNFCCC). The wetland strategy and action plan aim at the establishment of new Ramsar sites, the restoration of existing ones and the awareness raising programs about the importance and the urgently needed preservation of wetland ecosystems in Morocco.

Morocco is a party to the CBD since ratification in 1995. The Convention aims at conserving biological diversity, using its components sustainably and sharing the benefits arising out of the utilization of genetic resources in a fair and equitable manner, including appropriate access to genetic resources and appropriate transfer of relevant technologies, taking into account all rights over those resources. Box 1 presents selected items from the preamble and several articles of the CBD because of high relevance to this chapter.

Box 1: Convention on Biological Diversity/Preamble, Articles 8, 9, 10, 15

Preamble: Contracting Parties:

Concerned that biological diversity is being significantly reduced by certain human activities,

Aware of the general lack of information and knowledge regarding biological diversity and of the urgent need to develop scientific, technical and institutional capacities to provide the basic understanding upon which to plan and implement appropriate measures,

Noting that it is vital to anticipate, prevent and attack the causes of significant reduction or loss of biological diversity at source,

Noting further that the fundamental requirement for the conservation of

biological diversity is the *in-situ* conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings,

Noting further that *ex-situ* measures, preferably in the country of origin, also have an important role to play,

Recognizing the close and traditional dependence of many indigenous and local communities embodying traditional lifestyles on biological resources, and the desirability of sharing equitably benefits arising from the use of traditional knowledge, innovations and practices, and

Determined to conserve and sustainably use biological diversity for the benefit of present and future generations.

Article 8. *In situ* Conservation

Each Contracting Party shall, as far as possible and as appropriate:

(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;

(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;

(f) Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, inter alia, through the development and implementation of plans or other management strategies;

(h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;

(j) Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices.

Article 9. *Ex situ* Conservation

Each Contracting Party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing *in situ* measures:

(a) Adopt measures for the *ex situ* conservation of components of

biological diversity, preferably in the Country of origin of such components;

(b) Establish and maintain facilities for ex-situ conservation of and research on plants, animals and micro-organisms, preferably in the Country of origin of genetic resources; and

(c) Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions.

Article 10. Sustainable Use of Components of Biological Diversity

Each Contracting Party shall, as far as possible and as appropriate:

(a) Integrate consideration of the conservation and sustainable use of biological resources into national decision-making;

(b) Adopt measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity;

(c) Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements; and

(d) Support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced.

Article 15. Access to Genetic Resources

1. Recognizing the sovereign rights of States over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation.

2. Each Contracting Party shall endeavor to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of this Convention.

https://www.cbd.int/doc/legal/cbd-en.pdf

Ten years after the CBD was opened for signature, in the sixth Conference of the Parties (COP) held in April 2002, the 2002-2010 CBD Strategic Plan was developed in order to guide further implementation of the Convention at the global, regional and national levels. The main purpose of the plan is to halt the loss of biodiversity in an effective manner. Recognized as a vital component of the world's biological

diversity, an essential resource for the planet and for their vital role in maintaining environmental balance and ecosystem stability, plants received particular emphasis.

In synchronization with the CBD Strategic Plan, a Global Strategy for Plant Conservation 2002-2010 (GSPC), with 5 objectives and 16 targets, is prepared and adopted. The main purpose of this Strategy is to halt the destruction of the plant diversity that is so essential to meet the present and future needs of humankind. The 5 objectives of the GSPC are: a) understanding & documenting plant diversity; b) conserving plant diversity; c) using plant diversity sustainably; d) promoting education & awareness about plant diversity; and e) building capacity for the conservation of plant diversity. More specifically, target 5 of the strategy calls for the protection of 50% of the most important areas for plant diversity by 2010.

The same sixth COP designated the International Union for the Conservation of Nature (IUCN) and Plant life International as partners with governments for the implementation of the Strategy. In 2009, the CBD Secretariat published a global report on the status of the world's plant conservation. In 2010, the first on-line list of all of the world's known plant species names is published as an achievement of Target 1 of the GSPC (The plantList.org). However, many of the GSPC targets have not been attained. Consequently, an updated revised GSPC 2011-2020 keeping the same structure of targets and associated objectives was developed and presented for approval at the CBD's 10th meeting of the Conference of Parties, in Nagoya, Japan in September 2010. This revised GSPC is an integral part of the broader framework of the Strategic Plan for Biodiversity 2011-2020, particularly the Aichi biodiversity targets.

The Convention on the Conservation of European Wildlife and Natural Habitats, commonly referred to as the Bern Convention came into effect in 1982. Morocco ratified the convention in 2001 as a non-member country of the European council. The Convention is a binding legal instrument in the field of nature conservation, covering most of the natural heritage of the European continent and extending to some States of Africa. The Convention aims at conserving wild flora and fauna and their natural

habitats, particularly those in need for preservation for future generations, as well as to promote European co-operation and coordinated research in this field.

Article 5 of the convention states, "Each Contracting Party shall take appropriate and necessary legislative and administrative measures to ensure the special protection of the wild flora species specified in Appendix I. Deliberate picking, collecting, cutting or uprooting of such plants shall be prohibited. Each Contracting Party shall, as appropriate, prohibit the possession or sale of these species." Endangered and vulnerable species, listed in the Convention appendices, have received special attention with Appendix 1 listing strictly protected flora species. As explained by Heywood (1999), Appendix 1 (Strictly Protected Plant Species) of the Convention lists 500 species, extended in 1996 to include an additional 107 species from Central and Eastern Europe. As also noted by the author, the list includes some of the wild relatives of European cultivated plants (Heywood, 1999). Many of the species listed in the Appendix of the Bern Convention occur in Morocco. In the conclusion of his article on the implementation of the Bern Convention in Morocco, de Sadeleer (2008) recognized the legislative efforts made for a better conservation of the Country's biological diversity. However, the author added that a correct application of the Convention implies that further efforts are needed (de Sadeleer, 2008).

In 2002, Morocco signed the International Treaty on Plant Genetic Resources for Food and Agriculture adopted by the Thirty-First Session of the Conference of the Food and Agriculture Organization of the United Nations (ITPGRFA) in November 2001. The Treaty aims at recognizing the enormous contribution of farmers to the diversity of crops that feed the world; establishing a global system to provide farmers, plant breeders and scientists with access to plant genetic materials; ensuring that recipients share benefits they derive from the use of these genetic materials with the countries where they have originated. The main provisions of the Treaty are the Multilateral System, Access and Benefit Sharing, Farmers' Rights and Sustainable Use. It was until July 2006 that Morocco ratified the Treaty, entering into force in Morocco in October 2006.

In 2011, Morocco signed the CBD Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, and ratified the protocol in July 2013. In Morocco, the Nagoya protocol entered into force in October 2014.

National Framework (Studies, Programs, Strategies, Legislation, and Charters)

In 1932, Morocco promulgated a dahir (decree) on protected areas resulting in the creation of Toubkal National Park in 1942, Tazekka National Park in 1950 and Souss-Massa National Park in 1991. The creation of these parks confirms the Country's concern with the conservation of natural resources. However, since the advent of the Rio summit in 1992, biodiversity conservation and sustainable use have become a central focus. Like the rest of the Parties, Morocco has engaged in a wide range of actions called for by the Convention. In fact, since Morocco's ratification of the CBD, significant progress has been achieved in the Country in terms of legal, political reforms, environmental awareness and policy.

In 1998, the Forestry administration (Haut Commissariat aux Eaux et Forêts) drafted the National Forest Program as a strategic framework for the sustainable development of the forest sector by 2020. One of the specified short-term objectives was the ability to effectively stop and reverse the degradation of natural and forest areas with biodiversity protection through appropriate management and valorization of its economic potential as long-term objective. One of the major policy measures issued in this regard was the promulgation of the decree n° 2-99-626 (Bulletin Officiel n° 4704, 1999) related to the creation of the National Forestry Fund (Fonds National Forestier) which can be used, among others, for the compensation of deferred grazing on state forests. In 2002, a ministerial decree (2-5-2002, Bulletin Officiel n° 5000, 2002) was issued to allow the implementation of the above decree stipulating that the compensation is provided to forest users organized into cooperatives or

associations. Concerned users are determined through the articles 21 and 22 of the dahir of October 10, 1917 on forests.

In 2003, Morocco issued two laws with relevance to biodiversity conservation including plant diversity. Published in the Bulletin Officiel n° 5118 of June 19, 2003, these laws are the 11-03 law on the protection of the environment, and the 12-03 law on environment impact studies. The first law has clear provisions for protection of national biodiversity as stated in Section 2 on Fauna, Flora and Biodiversity of chapter III regarding the Protection of Nature and of Natural Resources. Article 20 states that fauna, flora and biodiversity should be protected through rational management in order to protect all species and to guarantee the ecological balance.

Article 21 states that all activities that may jeopardize animal and plant species or their natural environment are not allowed or subject to prior administrative permission in accordance with legislative and statutory provisions. Article 22 presents the different areas defined by legislative provisions including a) the list of animal and plant species subject to special protection, b) the permanent or temporary prohibition of any activity that may prevent the protection of rare, threatened or endangered species as well as their natural environment, c) the conditions for exploitation, marketing, use, transport and export of the species referred to in the previous paragraph, and d) the conditions for the introduction, from whichever origin, of any animal or plant species that may jeopardize protected species and their natural environment.

Articles 23, 24, 25, 26 concern the protection of public and/or private forests considered of common public interest. The administration and individuals have a duty to protect forests and to exploit them in such a way as to guarantee their balance and the respect of the ecosystems. Management plans and development and exploitation work must integrate the environment concerns so that their economic, social, cultural or recreational use should not jeopardize the environment. Forests must be protected against all forms of degradation, pollution or destruction caused by overexploitation, overgrazing, fire, disease or the introduction of unsuitable species. Deforestation is not allowed without prior permission

from the administration in the conditions provided for by the legislative and statutory provisions concerning forestry (Law 11-03).

Article 5 of Chapter II of the Law 12-03 on Environmental Impact Studies stipulates, "The objective of the environmental impact study is to evaluate, in a systematic and preliminary way, the possible repercussions, the direct and indirect, temporary and permanent impacts of the project on the environment and particularly on man, fauna, flora, soil, water, air, climate, the natural environment and the biological balance, on the protection of goods and historical sites and possibly on the comfort of the neighborhood, hygiene, public sanitation and security while taking into consideration the interactions between these factors."

In 2010, Morocco issued the Law n° 22-07 regarding protected areas as defined in the Dahir n° 1-10- 123 (July 16, 2010). The law aims at categorizing protected areas particularly national parks, of which the number stands currently at 11 parks. The law is an enabling measure for the integration of protection and conservation concerns with development objectives. In addition, Morocco elaborated the National Charter on Environment and Sustainable Development (CNEDD) in 2010. This charter turned into the Framework Law 99-12-14 adopted by the parliament in February 2014 and published in the Bulletin Officiel of March 2014.

In 2011, Morocco issued the Law n° 29-05 (Bulletin Officiel n° 5962) on the Protection of Endangered Species of Flora and Fauna and on the Regulation of their trade as adopted in the two chambers. With this law, Morocco determine national obligations under CITES and provides a list of protected species for which importing, capturing, and sales are regulated. Such measures may contribute to a better implementation of CITES convention as well as an insurance that trade and commercial exploitation of wildlife products including plants cannot be done at the expense of the species survival. However, it is in June 2015 that the decree for the application of the law was promulgated (Bulletin Officiel n° 6366). This legislation represents a major step forward in Morocco's protection of the natural heritage, insofar as it allows better control of the conservation of rare and endangered species of flora and fauna. It sets out the categories of

nationally threatened species, the conditions of their trade and the measures of their sampling in the Moroccan natural environment, as well as the conditions for their introduction or reintroduction in these environments (Dakki et al., 2015). With respect to plant species, the formally issued list includes nine species only as indicated on Table 8. Although the number is extremely low compared to the number of rare and threatened plant species in need for protection and also compared to the list of about 700 plant species protected under the Bern Convention, but it is a start.

Table 8. Plant species protected under the 29-05 Law

Plant family	Scientific name	Moroccan name	Moroccan name
Asteraceae	*Anacyclus pyrethrum*	tiguendezt	تكندزت
Cupressaceae	*Cupressus atlantica*	imejjid, azel	إمجيض، ازل
Cupressaceae	*Juniperus thurifera*	tawalt, lhor	توالت، لحر
Fabaceae	*Acacia gummifera*	tadout,	تدوت
Fagaceae	*Castanea sativa*	qastal	قسطال
Pinaceae	*Pinus nigra subsp. Mauritanica*	nigro	نيكرو
Pinaceae	*Abies maroccana*	choh	شح
Rosaceae	*Pyrus mamorensis*	njach	نجاش
Taxaceae	*Taxus baccata*	dakhch, iguen	دخش، إيكن

At last, Article 31 of Morocco's new constitution adopted in 2011 stipulates the right of every citizen to a healthy environment while Article 35 stipulates sustainable development and preservation of natural resources.

In December 2012, Morocco signed the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization and promulgated the law n° 13-12 for the protocol approval in June 2013 through the Dahir n° 1-13-58 of June 17, 2013. In June 2015, the Country adopted a law to protect its coastline, and is

currently carrying out actions to develop legislation for implementing the Nagoya Protocol.

Strategies

In 1996, Morocco established the Master Plan for Protected Areas (Plan Directeur des Aires Protégées du Maroc – PDAPM). The objective of this plan is the establishment of protected areas representative of the 40 major natural ecosystems of the Country using both ecological and socio-economic considerations. The implementation of the plan strengthened the existence of old parks by the creation in 2004 of four other national parks namely: AI Hoceima (AI Hoceima Province), Talassemtane (Chefchaouen Province), Ifrane (Province of Ifrane), High Atlas Oriental (Errachidia and Khénifra provinces). The National Park Khnifiss, established in 2006, is the first national park in the Saharan provinces. In April 2008, the National Park Khénifra was created resulting in a total area of about 750,000 ha. Currently, the number of national parks in Morocco stands at 11.

In 2004, Morocco elaborated the first Action Plan for the conservation and sustainable use of national biodiversity. The series of actions of the Plan were conceived to respond to the national strategic objectives for conserving national biodiversity and reducing the pressure on each of its components. This first strategy and action plan were developed through the organization of four thematic workshops (terrestrial, marine, wetlands biodiversity, and surveillance indicators) under the supervision of the Secretariat d'Etat Chargé de l'Environnement (SECE, 2004).

In 2014, a revised and updated National Biodiversity Strategy and Action Plan 2016-2020 (MDCE, 2014a) was established. This revised strategy takes into consideration the CBD strategic plan 2011-2020 and the Aichi objectives while integrating national specificities. With the global biodiversity framework taken into account and considering biodiversity as a pillar for sustainable development and the well-being of Moroccan society. The 6 strategic lines of the NBSAP 2016-2020 are a) strengthening the conservation of species, ecosystems and the services they provide, b)

ensuring the sustainable use of biodiversity and biological resources, c) contributing to the improvement of living conditions of the Moroccan people, d) strengthening biodiversity governance, e) improving, enhancing and sharing national biodiversity knowledge, and f) promoting attitudinal and behavioral changes among citizens towards national biodiversity heritage (MDCE, 2014a). The NBSAP includes 26 national targets mapped to relevant global targets, and which touch upon the environmental, social and economic dimensions of sustainable development. The four thematic areas covered are forestry, agriculture, marine sectors, and climate change. Decentralized biodiversity governance is encouraged through Morocco's 12 administrative regions instituted since 2015.

Additional sectorial strategies, currently under implementation, include the Green Morocco Plan, the Halieutis Plan, the National Strategy for Forestry Development, the Master Plan for Reforestation, the Program of the National Agency for the Development of Aquaculture, and the National Charter for Sustainable Tourism. There are also environment – centered national strategies including the National Strategy for Improvement of the Environment, the National Strategy for Environment, and the National Strategy for Sustainable Development.

One of the most recent strategies launched in Morocco is the strategy on wetlands 2015-2024. The Country's Wetland Strategy and Action plan 2015-2024 aims at the sustainable and integrated management of wetlands to ensure the improvement of their ecological heritage and their ecosystem services. One of the quantified target of the strategy is the inscription of 30 new sites to the Ramsar list to add to the 24 sites currently present in Morocco. As noted before, wetlands are rich in aquatic as well as terrestrial plants. Improving the heritage values and ecological functions of wetlands stands as a major of the strategy with two objectives by 2024 a) the significant improvement of the conservation status of natural wetland habitats and b) the establishment and implementation of national plans for the rehabilitation and sustainable management of wetlands' flora and fauna (Dakki et al., 2015).

The department of environment is responsible for the implementation of the CBD. The National Committee on Biodiversity created in 1998, not

benefiting from any legal status, oversees the implementation of the NBSAP, supported by a substantial capacity development plan developed in tandem with the NBSAP. The management of protected areas in Morocco is ensured by the Haut Commissariat aux Eaux et Forêts et à la Lutte contre la Désertification (Aghnaj et al., 2012).

Adaptation to Climate Change and Implementation of the Nagoya Protocol

Because of its geographical situation, Morocco is affected by climate change and the Country's vulnerability is increasingly growing as manifested in several phenomena. These include the global warming average over the entire territory estimated at 1 °C, the temporal and spatial variability of rainfall with a significant reduction between 3% and 30% depending on the areas, an intensification of extreme events such as floods, droughts, a tendency to rising heat waves and less cold waves, and a rising sea level. According to the Directorate of National Meteorology (DNM), climate projections for Morocco foresee an increase in average summer temperatures of 2 to 6 °C and a 20% decline in average rainfall by the end of the century (MDCE, 2014c). To meet and to contribute to the UNFCCC, Morocco has developed a national vision around the following six strategic pillars:

a) Strengthening the legal and institutional framework.
b) Improving knowledge and observation.
c) Territorial declination taking into account regional specificities and the active engagement of communities in the climate change adaptation and mitigation.
d) Prevention and reduction of climate risks through sector - adaptation actions.
e) Awareness, empowering of actors and capacity building at all levels and for all actors.

f) Promotion of research, innovation and technology transfer (MDCE, 2014c).

Recently, Morocco established a National Climate Change Competence Centre (4C Maroc) as a permanent and structured network of cooperation and bringing together the efforts and data from public institutions, local authorities, universities and the private sector to strengthen capacities of Morocco on adaptation to climate change (https://www.giz.de/en/worldwide/27018.html). Based on the 2016 Climate Change Performance Index, Morocco is ranked the world's sixth best Country and is the only non-European Country in the top 20 (Burck et al., 2015). In fact, Morocco, already with a relatively good ranking in the previous year, improved 1 rank to position 10 to secure a top 10 placement (Burck et al., 2015). The Country also submitted one of the few INDCs7 to receive a relatively good evaluation by experts. Based on standardized criteria, the index evaluates and compares the climate protection performance of 58 countries that together are responsible for more than 90% of global energy-related CO_2 emissions (Burck et al., 2015).

In Morocco, the adaptation to climate change program is implemented by the Environment department, the Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Desertification (HCEFLCD) in partnership with GIZ-Germany. While the program in general aims at establishing adaptation to climate change approaches, Morocco's program aims at providing the country with instruments for capacity strengthening and establishment of legislative and institutional frameworks to ensure sustainable use and valorization of ecosystems services and genetic resources (MDCE, 2014c). The program consists of three major components a) protection and sustainable valorization of ecosystems services and biodiversity, b) development of regional information and monitoring systems on biodiversity, and c) development of the legal and institutional frameworks regarding the Nagoya protocol (MDCE, 2014c). In fact, one of the main objectives of the NBSAP 2016-2020 is the adoption of the legislative and institutional framework necessary for the implementation of the Nagoya Protocol taking into account the sustainable

development and fair redistribution of benefits of trade among the different components of society as stated in the Protocol.

From Conserving Habitats to Conserving Species

The International Union for Conservation of Nature's definition of a protected area is the most widely recognized and adopted on both national and international levels. Protected areas submitted to the World Database on Protected Areas (WDPA) must conform to the IUCN definition to receive their designation. "A protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008). The definition covers all types of protected areas, therefore replacing all previous IUCN definitions of a protected area including the former classification of marine protected areas.

According to FAO, "Protected areas are an effective tool for conserving species and ecosystems. They contribute substantially to the long-term provisioning of services and the conservation of habitats and ecosystems, which are crucial for sustaining livelihoods at local, regional and global scales. Protected areas are crucial for the conservation of terrestrial, freshwater and marine environments. Their management and planning should involve all stakeholders, in particular the rural populations surrounding them and most affected by their presence and should benefit from the alternative sources of employment and economic activities they potentially provide (http://www.fao.org/biodiversity/cross-sectoral-issues/protected-areas/en/).

At the start of the 20th century, there were only a handful of protected areas in the world, although many have existed for generations. Over time, protected areas have become a mainstay of biodiversity conservation as well as contributing to people's livelihoods. Today, there are approximately 200,000 protected areas in the world, which cover around 14.6% of the world's land and around 2.8% of the oceans). According to

Heywood (2015a), the protected area approach is considered the cornerstone of any country's conservation strategy.

According to Aghnaj et al. (2012), between 1993 and 1995, Morocco conducted a national study on protected areas covering all natural ecosystems of the Country. The study allowed an assessment of main natural habitats, an assessment of the status of threatened, endemic and rare fauna and flora species, the identification of a national network of Sites d'Intérêt Biologique et Ecologique (SIBE) for the establishment of the master plan for protected areas and propositions of management plans for identified SIBEs (Aghnaj et al., 2012). As explained by Aghnaj et al. (2012), the study highlighted both the richness and the biological diversity of the Country as well as the extent of threat. It has shown that the Moroccan forests are the founding elements of the Country's ecological wealth containing two thirds of the plants and one third of the animal species.

The study opted directly for an ecosystem approach that offers several advantages in contrast to the species approach. Ecosystem approach allows the conservation of a maximum number of species of an ecosystem where they find optimal ecological conditions for their development (Benabid, 2000). In addition, the protection of particular species pass by the protection of the entire ecosystem as whole. The selection of protected areas includes several criteria including representativeness, biodiversity, ecological, patrimonial and socio-economic values, surface area, disturbances, threats, management possibilities, physical and cultural features, land use, and future development. The process resulted in the establishment of a network of more than 160 sites (SIBE in French is the acronym used to refer to these sites) grouped in three priority groups. The priority one group covered 48 sites, the priority 2 category included 50 sites and the priority 3 group concerned 62 sites.

Priority 1 sites, considered most representative and richest in biodiversity, need immediate protection measures within delays not exceeding 5 years while delays for sites of priority 2 and 3 not exceeding 10 years (Aghnaj et al., 2012).

Although some of the SIBE have initially been identified for biodiversity aspects other than plants, their selection, in itself, implies the conservation of plants constitute an integral part in selected sites. SIBE network constitute a global frame for *in situ* conservation in Morocco. Some of these SIBEs have received the Ramsar status. Most importantly, some of them have become Important Plant Areas (IPAs) based on IUCN criteria and categories (Taleb & Fennane, 2011). More than two thirds of SIBEs have factsheets with useful information accessible at the Clearing House Mechanism (CHM) for CBD in Morocco (cbd.net). Unfortunately, only a small number of SIBEs benefited from research efforts with scientific articles as outputs.

The three following tables present basic information on these SIBEs with emphasis on their floristic importance. Table 9 focuses on terrestrial SIBEs (01-77), Table 10 presents wetland SIBEs (H01-H43), and Table 11 presents SIBEs in the Mediterranean and Atlantic coastlines (L01-L41). The original list is accessible at the CHM-Maroc.

Table 9. Terrestrial SIBEs by name, priority, overlap, based on the 2015 administrative 12 regions

SIBE Type	SIBE Name	Priority	Overlap/IPA	Region 2015	Province (commune)	References
01	Perdicaris	2	-	1	Tanger -Asila	Factsheet
02	Dar Ben Karrich	3	-	1	Tétouan (Dar Ben Karrich)	-
03	Jbel Lahbib	3	-	1	Tétouan (Jbel Lehbib)	-
04	Khemis Es-sahel	3	-	1	Larache (Khemis Essahel)	-
05	Jbel Bouhachem	1	MA01-IPA	1	Chefchaouen	Factsheet
06	Brikcha	2	-	1	Ouazzane	Factsheet
07	Souk El Had	3	-	1	Ouazzane (Moqrissat)	-
08	Jbel Tizirane	2	-	1	Chefchaouen (Bab Berred)	Factsheet
09	Koudiat Tidighine	2	-	1	Al Hoceima (Issaguen)	-

SIBE Type	SIBE Name	Priority	Overlap/IPA	Region 2015	Province (commune)	References
10	Jbel lalla Outka	1	-	3	Taounate (Lalla Outka)	Factsheet
11	Jbel Amergou	3	-	1	Ouazzane (Zoumi)	-
12	Azrou Akechar	2	-	3	Taza (Aknoul)	Factsheet
13	Jbel Gourougou	3	-	2	Nador (Bni Chiker)	-
14	Beni-Snassene	1	MA04-IPA	2	Berkane	Factsheet, Achhal El Kadmiri et al. 2004
15	Chekhar	3	-	2	Jerada (Tiwisst)	-
16	Lalla Chafia	1	-	2	Jerada (Aïn Bni-Mathar)	Factsheet
17	Lalla Mimouna	3	-	2	Taourirt (Debdou)	-
18	Jbel Ouarirt	3	-	3	Taza (Galdamane)	-
19	El Aderj	2	-	3	Sefrou (El Adrej)	Factsheet
20a	Bou Iblane I	1	MA06-IPA	3	Taza (Bouiblane)	Factsheet
20b	Bou Iblane II	2	-	3	Taza (Bouiblane)	Factsheet
20c	Bouzemmour	3	-	2	Guercif	-
21	Bou Naceur	1	MA05-IPA	3	Taza (Barkine)	Factsheet, Rahou, 1996
22	Outat El Haj	3	-	3	Boulemane	-
23	Jbel Tichoukt	1	MA08-IPA	3	Boulemane (Skoura Mdaz)	Factsheet
24	Takeltount	3	-	3	Sefrou	-
25	Jaâba	2	Ifrane National Park	3	Ifrane	Factsheet
26	Aghbalou n'Arbi	2	-	3	Ifrane (Timahdite)	Factsheet
27	Talaghine	3	-	8	Midelt (Itzer)	-
28	Tizi n'Aït Ouirra	2	-	5	Beni Mellal (Ksiba)	Factsheet
29	Jbel Tazerkount	2	-	5	Azilal (Afourar)	Factsheet
30	Jbel Zerhoun	3	-	3	Meknès (Oualili)	-
31	Maâmora	1	MA19-IPA	4	Kénitra, Rabat	Aafi et al. 2005
32	Oued Korifla	3	-	4	Skhirat-Temara	-
33	Oued Cherrat	1	-	4	Benslimane	Factsheet

Table 9. (Continued)

SIBE Type	SIBE Name	Priority	Overlap/IPA	Region 2015	Province (commune)	References
34	Tsili	3		4	Khémisset (Rommani)	-
35	El Harcha	1	-	4	Khémisset	Factsheet
36	Kharrouba	1	-	4	Khémisset	Factsheet Dallahi et al. 2016a, 2016b
37	Ment	3	-	5	Khénifra (Aguelmous)	-
38	Bou Riah-Beddouz	1	-	4	Khémisset	Factsheet
39	Khatouat	2		6, 5	Settat/ Khouribga	Factsheet
40	Ouardane	2	-	5	Khénifra (Aguelmous)	Factsheet
41	Beni Zemmour	1	-	5	Khouribga (Beni Zrantel)	Factsheet
42	Deroua	2	-	5	Fquih Ben Salah	Factsheet
43	Marais de la Palmeraie de Marrakech	2	-	7	Marrakech	Factsheet Belaqziz, 2006
44	Msabih Talâa	2	-	7	Youssoufia (Sidi Chiker)	Factsheet
45	Jbel Taghioult	2	-	3	Boulemane (Qsabi Moulouya)	Factsheet
46	Jbel Ayachi	2	MA11-IPA	8	Midelt	Factsheet Taleb & Fennane, 2008
47	Grottes d'Akhyam	3	-	8	Tinghir	-
48	Boutferda	3	-	5	Beni Mellal	-
49	Tamga	1	MA15-IPA	5	Azilal (Tilouguite)	Factsheet
50	Aqqa Wabzaza	1	MA15-IPA	5	Azilal (Ait Mhamed)	Factsheet
51	Imi n'Ifri	3	-	5	Azilal (Demnate)	PNUD-AESVT, 2006

SIBE Type	SIBE Name	Priority	Overlap/IPA	Region 2015	Province (commune)	References
52	Sidi Meskour	3	-	5	-	-
53	Vallée de Telouat	3		8	Ouarzazate (Telouat)	-
54	Aghbar	1	MA17-IPA	7	Al-Haouz (Sebt Aghbar)	Factsheet
55	Tichka	3	-	9	Taroudant	-
56	Aïn Asmama	1	-	9	Agadir Ida-Outanane (Tiqqi)	Factsheet Labbaci & Kabbachi, 2013
57	Jbel Amsittene	2	-	7	Essaouira	Factsheet
58	Idemine	1	-	9	Agadir Ida-Outanane (Idmine)	Factsheet
59	Tafinegoult	1	-	9	Taroudant	Factsheet
60	Assads	3	-	9	Taroudant (Assads)	-
61	Dar Lahoussine	3	-	9	Tiznit	-
62	Jbel Lkest	2	MA18-IPA	9	Tiznit	Factsheet, Aboudi, 1987
63	Anezi	3	MA18-IPA	9	Tiznit (Anezi)	-
64	Aït Er-rkha	3	-	10	Sidi Ifni	-
65	Bou Timezguida	3	-	10	Sidi Ifni	-
66	Jbel Sargho	3	-	8	Tinghir	-
67	Oued Todra	3	-	8	Tinghir	-
68	Gorges Ziz-Elkheng	3	-	8	Errachidia	-
69	Jbel Krouz	1	MA13-IPA	2	Figuig (Abbou Lekhal)	Factsheet
70	Merzouga	1	-	8	Errachidia	Factsheet
71	Msissi	3	-	8	Tinghir	-
72	Oued Mird	1	-	8	Zagora (Tagounite)	Factsheet
73	Oasis de Tissint	2		9	Tata (Tissint)	Factsheet
74	Iamoun	3	-	9	Tata (Akka)	-
75	Aït Oumribt	1	-	10	Tata (Foum Lhisn)	Factsheet
76	Oued Tighzert	1	-	10	Assa-Zag	Factsheet
77	Msseyed	1	-	10	Tan (Msied)	Factsheet

Table 10. Wetland SIBEs (name, priority, overlap) based on the 2015 administrative 12 regions

SIBE Type	SIBE Name	Priority	Overlap	Region 2015	Province	References
H01	Oued Zegzel (Amont)	2	-	2	Berkane	
H02	Barrage Mohammed V	1	Ramsar 1980	2	Berkane, Nador	Factsheet
H03	Aïn Bou adel	2	-	3	Taounate	Factsheet
H04	Merja Bokka	3	-	4	Sidi Slimane	Factsheet
H05	Oued Fouarate	3	-	4	Salé	Factsheet
H06	Daya Mamora	1	-	4	Rabat, Kénitra	-
H07	Daya Sidi Bettach	2	-	4	Benslimane	-
H08	Barrage El Maleh	2	Ramsar 1980	4	Benslimane	Factsheet
H09	Dayet Erroumi	1	-	4	Khémisset	Factsheet
H10	Dwiyate	1	-	3	Moulay Yacoub	Factsheet
H11	Barrage Driss 1er	3	-	3	Taounate	Factsheet
H12	Oued El Bared	1	-	3	Sefrou	Factsheet
H13	Guelta Tamda	2	-	3	Sefrou	Factsheet
H14	Dayet Iffer	3	-	3	Ifrane	Factsheet
H15	Dayet Aoua	3	Ifrane NP	3	Ifrane	Factsheet
H16	Plan d'Eau Zerrouka I	3	-	3	Ifrane	Factsheet
H17	Oued Tizguit	1	-	3	Ifrane	Factsheet
H18	Dayet Ifrah	3	-	3	Ifrane	Factsheet
H19	Gorges d'Aazzi	2	-	3	Boulemane	
H20	Source de Tit Zill	2	-	3	Boulemane	Factsheet
H21	Aguelmam afennourir	1	Ramsar 1980, Ifrane NP	3	Ifrane	Factsheet
H22	Aguelmam n'Tifounassine	2	Ramsar 2005	3	Ifrane	Factsheet
H23	Plan d'eau d'Amghass	3	-	3	Ifrane	Factsheet
H24	Aguelmam Wiwane	3	-	3	Ifrane	Factsheet

SIBE Type	SIBE Name	Priority	Overlap	Region 2015	Province	References
H25	Aguelmam Sidi Ali Ta'nzoult	2	-	3	Ifrane	Factsheet
H26	Aguelmam Azegza	3	-	5	Khénifra	Factsheet
H27	Aguelmam Mi'Ammi	3	-	5	Khénifra	Factsheet
H28	Aguelmam Abekhane	3	-	5	Khénifra	Factsheet
H29	Barrage al-Massira	1	Ramsar 2005	6, 7	Settat, El Kelâa des Sraghna	Factsheet
H30	Sebkha Zima	2	Ramsar 2005	7	Youssoufia	Factsheet
H31	Sahb Al-Majnoun	3	-	7	Rehamna	Factsheet
H32	Cascades d'Ouzoud	3	-	5	Azilal	Factsheet
H33	Lac d'Isli	2	Ramsar 2005	8	Midelt	Factsheet
H34	Lac de Tislite	1	Ramsar 2005	8	Midelt	Factsheet
H35	Oued Lakhdar	2	-	5	Azilal	Factsheet
H36	Assif Reghaya	3	-	7	Al-Haouz	
H37	Assif n'Ouarzane	1	-	7	Al Haouz	Factsheet
H38	Assif n'Aït Mizaine	1	Toubkal N. park	7	Al Haouz	Factsheet
H39	Lac d'Ifni	2	Toubkal N. park	9	Taroudant	Factsheet
H40	Assif n'Tifnoute	3	-	9	Taroudant	Factsheet
H41	Source Tizi n'Test	3	-	9	Taroudant	Factsheet
H42	Barrage Al Mansour Addahbi	2	-	8	Ouarzazate	Factsheet
H43	Daya Tamezguidat	2	-	8	Errachidia (Merzouga)	-

Table 11. Coastline SIBEs (name, priority, overlap) based on the 2015 administrative 12 regions

SIBE Type	SIBE Name	Priority	Overlap/	Region	Province	References
L01	Embouchure Moulouya	1	Ramsar 2005	2	Berkane /Nador	Factsheet Hammada 2007
L02	Sebkha Bou Areg	2	Ramsar 2005	2	Nador	Factsheet Hammada 2007; Amini et al. 2008
L03	Cap des trois fourches	2	Ramsar 2005	2	Nador	Factsheet
L04	Parc National Al- Hoceima	1	National Park	1	Al Hoceima	
L05	Cirque de Jebha	3	-	1	Chefchaouen	-
L06	Côte Ghomara	3	-	1	Chefchaouen	-
L07	Koudiat Taifour	3	-	1	M'diq-Fnideq	-
L08	Lagune de Smir	3	-	1	M'diq-Fnideq	Cassar et al. 2005; Hammada 2007
L09	Jbel Moussa	1	-	1	M'diq-Fnideq	Factsheet
L10	Cap Spartel	3	-	1	Tanger-Asila	-
L11	Oued Tahadart	2	-	1	Tanger-Asila	Factsheet
L12	Marais de Larache	1	Ramsar 2005	1	Larache	Factsheet Hammada 2007
L13	Merja Oulad Skhar	2	-	1	Larache	Factsheet
L14	Merja Bargha	2	-	1	Larache	
L15	Merja Halloufa	2	-	1	Larache	Factsheet
L16	Merja Zerga	1	Ramsar	4	Kénitra	Factsheet Hammada 2007

SIBE Type	SIBE Name	Priority	Overlap/	Region	Province	References
L17	Sansouire du Sebou	3	-	4	Kénitra	Hammada 2007
L18	Sidi Boughaba	1	Ramsar	4	Kénitra	Factsheet, Benrah-moune & Dubruille, 2003
L19	Falaise de Sidi Moussa	2	-	4	Salé	Factsheet
L20	Ilots de Bou Regreg	2	-	4	Rabat	Factsheet
L21	Ilot de Skhirat	2	-	4	Skhirat-Témara	Factsheet
L22	Baie de Haouzia	3	-	6	El Jadida	-
L23	Jorf Lasfar	2	-	6	El Jadida	Factsheet
L24	Sidi Moussa-Oualidia	1	Ramsar 2005	6	Sidi Bennour	Factsheet
L25	Dunes d'Essaouira	1	Ramsar 2005	7	Essaouira	Factsheet
L26	Archipel d'Essaouira	1	Ramsar 2005	7	Essaouira	Factsheet Ibn Tattou 2010
L27	Embouchure Tamri	1	-	9	Agadir Ida-Outanane	Factsheet
L28	Cap Ghir	2	-	9	Agadir Ida-Outanane	Factsheet
L29	Parc National Souss-Massa	1	National Park	9	Agadir Ida Outanane-Tiznit	Errabih 1987
L30	Foum Assaka	1	-	10	Guelmim	Factsheet
L31	Plage Blanche	3	-	10	Guelmim	-
L32	Embouchure du Draa	2	Ramsar 2005	10	Tan	Factsheet
L33	Oued Chbeika	2	Ramsar 2005	10	Tan Tan	Factsheet
L34	Oued Amma Fatma	3	-	10	Tan Tan	-
L35	Oued El-waâr	3	Ramsar 2005	10	Tan Tan	-

Table 11. (Continued)

SIBE Type	SIBE Name	Priority	Overlap/	Region	Province	References
L36	Lagune de Khnifiss	1	Ramsar 2005, Khnifiss N.P 2006	11	Tarfaya	Factsheet Hammada 2007
L37	Pointe d'Awfist	2	-	11	Boujdour	Factsheet
L38	Hassi Touf	3		11	Boujdour	-
L39	Baie de Dakhla	1	Ramsar 2005	12	Oued Ed-Dahab	Factsheet
L40	Baie de Cintra	3		12	Oued Ed-Dahab	-
L41	Parc National de Dakhla	1	National Park	12	Aousserd	-

As noted before, not all SIBEs were established for plant protection, some were for fauna diversity and protection, birds, landscapes, etc. but they all provide a framework the understanding of which helps with grasping the importance of conservation and the complex relationships of all biodiversity components. A quick look at the 3 tables on Morocco's SIBEs reveals the following aspects.

First, the diversity of SIBEs is significant covering terrestrial, wetland, and coastal areas. The 77 terrestrial SIBEs comprise important areas with significant diversity located in mountains, oases, and valleys. The 43 wetland SIBEs include most wetland points throughout Morocco. T41 SIBEs on the Mediterranean and Atlantic coastlines clearly shows the importance of coastal ecosystems as habitats of general biodiversity.

Second, within each category, SIBEs are grouped into three priority level categories. The prioritization followed a set of criteria taking into account the national context and priorities, in particular the originality and importance of the SIBE at the local, national and international levels (Fennane, 2004). In addition, the priority level determines the type of management proposed for the site and the time frame for its implementation.

Third, the evolutionary process since the identification of the initial list of SIBEs in 1996 is quite revealing. Some SIBEs received the Ramsar status, others became Important Plant Areas, some sites turned into natural parks, hunting reserves, and some are still under their initially instituted designation. Among the Ramsar sites, there is the Khnifiss lagoon (L36) created in 1980. Additional sites (Embouchure Oued Drâa (L32), the embouchures of Oued Chbeika-Oued Al Waâr (L33, L35), and Dakhla bay (L39) have been established in 2005. These sites are considered important sites for water birds and recognized as being of significant value not only for Morocco but worldwide.

Fourth, although SIBEs are distributed unequally across regions of the Country, all regions are covered.

Fifth, research focusing on these SIBEs during the last 20 years is rather weak. Some SIBEs are fortunate because they were subject to study and their species inventoried as parts of thesis work or small-scale project, but most SIBEs of priority 2 and 3 were not that fortunate. Examples of studied SIBEs include Aïn Asmama (Labbaci & Kabbachi, 2013), Beni Snassene (Achhal El Kadmiri et al., 2004), Kharrouba (Dallahi et al., 2016a, 2016b), Marais de la Palmeraie (Belaqziz 2006), Lagune de Nador (Amini et al., 2008), Archipel d'Essaouira (Ibn Tattou 2010), Maâmora (Ahayoun et al., 2015), Jbel Amssittene (Zine El Abidine et al. 2011).

The paucity of documents and references on SIBEs suggests the lack of research and the current gaps in knowledge on these habitats. Without this research and generated knowledge (benchmark studies, inventories, assessments), it is difficult, rather it is impossible to conceive or consider effective conservation measures.

From Sites of Biological and Ecological Interest (SIBEs) to Important Plant Areas (IPAs) in Morocco

Important Plant Areas (IPAs) are important international sites for wild plants and fungi, identified nationally for plant conservation based on

standard criteria. The development of IPAs came about in response to the lack of concentrated efforts on conserving plant diversity. The IPAs do not have any legal nature but they constitute a framework for targeting sites and assessing the effectiveness of conservation activities for plants. In addition, IPAs can be integrated into conservation initiatives and networks such as protected areas. Target 5 of the Global Strategy for Plant Conservation 2010-2020 calls for the protection of at least 75% of the most important areas for plant diversity with effective management in place for conserving plants and their genetic diversity. Consequently, countries have identified national important areas for plant diversity in order to contribute to internationally important areas for plants with the objective of protecting them based on national priorities and capacities and taking into account differences in plant diversity worldwide.

Morocco, among 13 Mediterranean countries, participated in the regional workshop held in Malaga in 2003. As recommended, Mediterranean countries organized their national workshops to set their priorities. The first national workshop on Important Plant Areas in Morocco was held in Rabat, October 2004 in partnership with IUCN and Plantlife International (Fennane, 2004). As noted by Fennane (2004), the workshop is an opportunity for Morocco to accelerate diverse activities and programs on protected areas, studies, and legislation. For the IUCN and Plantlife International, Morocco's component is important for the success of their program on IPAs in the Mediterranean Basin given the place of Morocco in the region. According to Fennane (2004), the main objective of all these efforts is the identification and protection of an international network of Important Plant Areas before 2010 as part of the implementation of the GSPC 2002-2010. One of the main challenges faced by participants was to succeed in the difficult conciliation between IUCN and Plantlife International's definitions and approaches and national and regional specificities (Fennane, 2004).

The Mediterranean Basin is undoubtedly one of the largest global hotspots in the world and well recognized for its significant plant diversity.

As indicated in Radford et al. (2011), around 10% of the world's vascular plants (25,000) are present in the Mediterranean Basin on less than 2% of the Earth's surface and half of these species are found nowhere else on earth. A desk-based study on Important Plant Areas (IPAs) in the south and east Mediterranean region was completed by the IUCN Centre for Mediterranean Cooperation, Plantlife International and WWF with country experts from Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia. This study identified and mapped 128 preliminary IPAs, then crowned by the development of a project on "Conserving wild plants and habitats for people in the South and East Mediterranean (IPA-Med) focusing on the management of sites and raising awareness in North Africa, the Middle East, the Balkans and Turkey which should begin in 2014.

Important Plant Areas (IPAs) are internationally important sites for wild plants and fungi, identified at national level using standard criteria**.** Initially developed to address the lack of focus on conserving plant diversity, IPAs provide a framework to assess the effectiveness of conservation activities for plants, and target sites for future action. They support existing conservation programs such as protected area networks and the CBD GSPC **(**Radford et al., 2011).

As a major contributor to the great biodiversity of the Mediterranean Basin, Morocco has been part of the recent assessment of Important Plant Areas in the eastern and southern parts of the Mediterranean. In this assessment, Morocco identified 19 IPAs. These IPAs were selected from the existing network of SIBE, particularly those already considered SIBEs of prime priority (Table 12). Criteria used for their selection include richness in endemics. According to Menioui et al. (2013), Morocco's IPAs are characterized by an exceptional floristic richness with at least 1700 taxa widespread in these 19 priority conservation sites (Table 13).

Table 12. Morocco's IPAs Summary from individual factsheets

Site code	IPA - Name	Area (Ha)	Elevation range (m)	First threat (threat level)*	Second threat (threat level)*
MA01	Jbel Bouhachem	3700	1600-3200	A (1)	B (1)
MA02	Talassemtane National Park	60000	24-2170	E (1)	C (1)
MA03	Al Hoceima National Park	48460	0-2440	-	-
MA04	Beni Snassene	6150	1000-1600	A (1)	B (1)
MA05	Jbel Bou Naceur	14000	1600-3340	A (1)	B (1)
MA06	Jbel Bou Iblane	3700	1600-3200	A (1)	B (1)
MA07	Tazekka National Park	13737	1200-1980	A (1)	B (1)
MA08	Jbel Tichoukt	12500	0-2790	A (1)	B (1)
MA09	Ifrane National Park	125000	1300-2440	B (4)	-
MA10	Eastern High Atlas National Park	49000	1650-3077	A (1)	B (1)
MA11	Jbel Ayachi	20000	1900-3757	A (1)	B (1)
MA12	Jbel Maâsker	10000	1900-3265	A (1)	B (1)
MA13	Jbel Krouz	60000	900-1700	A (1)	-
MA14	Jbel Mgoun	500000	1500-4068	A (1)	B (1)
MA15	Tamga & Aqqa Wabzaza	8500	1100-2400	E (1)	-
MA16	Toubkal National Park	40000	1200-4167	A (2)	F (4)
MA17	Aghbar	50000	1300-3600	A (1)	B (1)
MA18	Jbel Kest, Anezi & Jbel Imzi	30000	200-2375	C (1)	A (1)
MA19	Maâmora	5000	80-200	D	A (2)

*Codes: for threats: Grazing = A, Deforestation = B, Agricultural intensification/expansion = C, Unsustainable exploitation = D, Afforestation = E, Tourism-recreation = F.

Codes for threat levels: High = (1), Medium = (2), Low = (3), Unknown = (4)

Source: Individual factsheets, Plantlife International.

The definition of IPA stated above summarizes key differences and complementarities between Morocco's concept of SIBE and the international notion of IPA.

Table 13. Morocco's IPAs by endemic, rare and very rare taxa

Site Code	IPA Name	Floristic richness	Endemic taxa	Rare taxa	Very rare taxa
MA01	Jbel Bouhachem	NA	16	14	20
MA02	Talassemtane National Park	747	47	19	26
MA03	Al Hoceima National Park	110	NA	NA	NA
MA04	Beni Snassene	NA	NA	NA	NA
MA05	Jbel Bou Naceur	556	92	5	10
MA06	Bou Iblane	500	25	9	8
MA07	Tazekka National Park	500	31	18	31
MA08	Jbel Tichoukt	300	22	7	9
MA09	Ifrane National Park	1015	253	13	24
MA10	Eastern High Atlas National Park	> 400	66	13	6
MA11	Jbel Ayachi	260	75	9	4
MA12	Jbel Maâsker	150	34	7	3
MA13	Jbel Krouz	261	2	7	7
MA14	Jbel Mgoun	500	54	7	10
MA15	Tamga & Aqqa Wabzaza	366	33	NA	NA
MA16	Toubkal National Park	536	164	NA	NA
MA17	Aghbar	500	45	7	13
MA18	Jbel Kest, Anezi & Jbel Imzi	NA	17	2	5
MA19	Maâmora	408	26	29	35

NA = Not available

Source: Taleb (2016) and IPA individual factsheets

First, in comparison with nationally determined SIBEs, IPAs are part of an international network for plant conservation. IPAs are recognized because of their international significance and over the borders' contribution to world diversity.

Second, IPAs are essentially plant-centered sites and primarily identified because of their wild plant richness and characteristics. Morocco's SIBEs were established because of their overall biodiversity, habitat, landscape value, and not necessarily for floristic importance. In some SIBEs, the floristic aspect held a secondary position or may have been completely absent in the identification criteria.

Third, while the identification process is carried out at the national level, used criteria are standardized across countries in comparison to national considerations and criteria used in identifying SIBEs.

Fourth, the IPAs' model is constructed with futurist prospects and users' perspective in the Mediterranean region and the world. As clearly stated in the executive summary, IPAs are not an optional extra and neither is their conservation. They support the livelihoods of many people and provide undervalued services such as water and flood control, carbon capture, the prevention of desertification and a reservoir of genetic species and diversity; all critically important for the Mediterranean region **(**Radford et al., 2011).

Morocco is undoubtedly a significant contributor to the Mediterranean plant richness. As such, Morocco is compelled to ensure the preservation, the sustainable use and the conservation of national endemics, particularly restricted range and mega endemics. Nineteen important plant areas are identified in Morocco as part of the IUCN priority sites for conservation in the Mediterranean Basin.

Rigorous updated floristic studies of these IPAs are necessary for future conservation assessments and monitoring. As indicated on Table 13, quantitative data even indicative are still lacking in the case of several IPAs (Jbel Bouhachem, Beni-Snassen, Jbel Kest, Jbel Anezi & Jbel Imzi). In addition, selected IPAs are host of threatened plants requiring constant assessments and monitoring (Table 14).

Table 14. Morocco's IPAs by group of threatened plants

Site Code	IPA Name	Nationally threatened endemic	Threatened near endemic	Threatened vascular plants
MA01	Jbel Bouhachem	10	1	11
MA02	Talassemtane National Park	3	5	8
MA03	Al Hoceima National Park	3	1	4
MA04	Beni Snassene	2	5	7
MA05	Jbel Bou Naceur	10	5	15
MA06	Jbel Bou Iblane	2	2	4
MA07	Tazekka National Park	12	7	19
MA08	Jbel Tichoukt	3	0	3
MA09	Ifrane National Park	54	75	129
MA10	Eastern High Atlas National Park	6	12	18
MA11	Jbel Ayachi	6	3	9
MA12	Jbel Maâsker	3	2	5
MA13	Jbel Krouz	2	1	3
MA14	Jbel Mgoun	18	8	26
MA15	Tamga & Aqqa Wabzaza	2	6	8
MA16	Toubkal National Park	25	38	63
MA17	Aghbar	7	5	12
MA18	Jbel Kest, Anezi & Jbel Imzi	4	7	11
MA19	Maâmora	5	9	14

Source: Compiled from IPA - Factsheets (Plantlife International) plus additional references.

Morocco's Biosphere Reserves

Initiated in the early 1970's, the UNESCO's Man and the Biosphere Programme (MAP) aims at establishing a scientific basis for the improvement of the relationship between people and their environments. Biosphere reserves are areas comprising terrestrial, marine and coastal ecosystems. Each reserve promotes solutions reconciling the conservation of biodiversity with its sustainable use. Biosphere reserves are 'Science for Sustainability Support Sites' – special places for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and

biodiversity management http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/.

Biosphere reserves are proposed and actually managed by national governments but internationally recognized. Biosphere reserves have three very different, but equal, aims: conservation of genetic resources, species, and ecosystems; scientific research and monitoring; and promoting sustainable development in communities of the surrounding region. All three of these aims are equally important in a biosphere reserve.

The World network of biosphere reserves counts 669 sites in 120 countries including 16 transboundary sites. Currently, Morocco possesses three national biosphere reserves and one transboundary biosphere. These include a) the Arganeraie biosphere reserve established in 1998, b) the Oasis du Sud Marocain designated in 2000, c) the Intercontinental Biosphere reserve of the Mediterranean designated in 2006, and d) the Atlas Cedar biosphere reserve designated in 2016. Table 15 compiles selected relevant information on the four biospheres.

Table 15. Selected characteristics of Morocco's four biosphere reserves

Item	Arganeraie	Oasis du Sud Marocain	Intercontinental biosphere (Moroccan section)	Atlas Cedar biosphere
Year of designation	1998	2000	2006	2016
Location	Southwest, bordered by the High and Anti-Atlas mountains, open to Atlantic in the west	East of the Country	Tingitane peninsula in the North	Central Atlas Mountains
Total area (ha)	2,568,780	7,185,371	-	1,375,000
Core area (ha)	110,000	908,581	64,000	130,000
Buffer zone (ha)	935,870	4,619,230	282,500	895,000

Item	Arganeraie	Oasis du Sud Marocain	Intercontinental biosphere (Moroccan section)	Atlas Cedar biosphere
Transition area (ha)	1,505,910	1,657,560	123,500	350,000
Altitude (meters above sea level	0 to + 2,000	680 – 4,071	Jbel Lakraa peaks at 2,159	Up to 3,700
Habitats and land cover	Semi steppe, forest and semi forested (red juniper, etc.)	High Atlas & Anti-Atlas forests; Acacia forests, desert steppes, sand dune habitats, date palms & associated agroecosystems	Deciduous forests	*Quercus ilex* forests, arid steppe of Haute Moulouya plain
Botanic interest Species	*Argania spinosa*, *Acacia gummifera* & *Dracaena draco* subsp *ajgal*, endemics of the biosphere	*Juniperus* sp.; *Acacia raddiana* & *A. ehrenbergiana*	Rare species including *Acer granatense*, *Alnus glutinosa*, *Betula celtiberica*	75% of the world's Atlas cedar tree population. Rich species diversity
Overlap (other protected areas such as SIBE, IPA, National parks)	National park of Souss-Massa + 12 SIBEs	SIBEs	National Park of Talassemtane + 4 SIBEs, IPA Jbel Bouhachem	3 National Parks (NP of Ifrane, NP of Khenifra, & NP of Haut Atlas Oriental) + SIBEs
Major threats	Overe-xploitation	Droughts, water scarcity, desertification	-	-
Research	Arganeraie ecosystem, argan tree, argan oil and uses	Some research activities in oasis areas focusing on water, biodiversity, local knowledge	The Rif	Atlas cedar ecosystem & tree subject to research

Ex Situ Conservation of Plants and Genetic Resources (Gene Banks, Botanic Gardens, Herbaria, Arboreta)

Having ratified the Convention on Biological Diversity in 1995, Morocco actively participated in the International Technical Conference on Plant Genetic Resources held in Leipzig in 1996 as a participant in the preparatory process and as an adherent to the International undertaking on plant genetic resources. The Country report to the conference noted that the Maghreb countries and Morocco in particular, are centers for genetic diversity of several genera (Birouk et al., 1995). The report cites the following:

Avena (with about 20 species including *A. maroccana, A. agadiriana, A. Atlantica, A. ventricosa, A. weistii, A. eriantha, A. barbata, A. Murphyi, A. longiglumis, A. hirtula*),
Medicago (with 16 species including *M. truncatula, M. scutellata, M. polymorpha, M. aculeata, M. tornata, M. murex, M. laciniata, M. rotata, M. secundiflora, M. sauvagei*);
Lupinus (*L. atlanticus, L. angustifolius, L. cosentinii*);
Trifolium (*T. fragiferum, T. repens, T. subterraneum*);
Aegilops (*Ae. ovata, Ae. triuncialis, Ae. ventricosa, Ae. triaristata, Ae neglecta, Ae. geniculata*);
Phalaris (*P. aquatica, P. minor*);
Hordeum (*H. murinum, H. spontaneum, H. bulbosum, H. leporinum*);
Triticum (*T. monococcum*);
Lathyrus (*L. articulatus, L. odoratus, L. tingitanus*);
Ononis (*O. natrix, O. pseudoserotina, O. alopecuroides, O. mogadorensis*);
Vicia (*V. articuata, V. ervilia, V. narbonensis*);
Astragalus, Bituminaria, Lotus, Stipa and *Eragrostis* (Birouk et al., 1995).

Morocco's Country report to the Second Report on Plant Genetic Resources presents the progress made since the first report, particularly in the area of *ex situ* conservation (Saidi et al., 2007). Among Morocco's

achievements, the report indicates the establishment of a long-term storage facility in 2002, the use of molecular markers and GIS in cereals germplasm evaluation, the conduct of regeneration activities, a better documentation of accessions held in the gene bank, and the development of Master's Degree programs focusing on conservation of genetic resources and natural resources management (Saidi et al., 2007).

Over the years, *ex situ* collections in Morocco have increased significantly either through new collecting expeditions, or through exchanges. According to the head of the Settat gene bank, the storage capacity of the facility is estimated at more than 80,000 accessions and it could serve as a national center for conservation and utilization of plant genetic resources in Morocco (Ouabbou et al., 2016). In a recent report, it is stated that currently the gene bank in Settat holds 54,000 accessions representing 126 different genera and 337 species (Ouabbou et al., 2016). According to the same source, among the conserved accessions, the genebank conserves 23394 lines of mutated durum wheat as a genetic stock. As pointed out, this gene pool is the only one preserved in the world (Ouabbou et al., 2016). As indicated on the Table 16, over 95% of total accessions belong to 14 genera (*Triticum*, *Hordeum*, *Medicago*, *Avena*, *Zea*, *Helianthus*, *Vicia*, *Oryza*, *Cucumis*, *Trifolium*, *Lens*, *Cicer*, and *Lupinus*).

Botanic gardens are definitely important in *ex situ* plant conservation. They provide context and frame suitable for growing, cultivating and preserving plant species that are threatened and /or at risk of extinction in natural habitats. Notwithstanding their role in public awareness and education regarding plants, botanic gardens can also play a vital role in restoration and rehabilitation of degraded habitats. Living collections of plant species provide opportunities for keeping genetic diversity for both conservation and research purposes. Most importantly, living collections may be the only alternative for safeguarding plants unsuitable for seed banking.

As noted in the second Country report on plant genetic resources for food and agriculture (Saidi et al., 2007), botanic gardens in Morocco concern collections of exotic and ornamental species. Gardens with

education functions include the garden of the Institut Agronomique et Vétérinaire Hassan II and the garden of the Ecole Nationale Forestière d'Ingénieurs, but they contain a number of rare or threatened species from Morocco. Based on the same Country report, it is suggested that with the exception of a few pastoral or forage species that have attracted the attention of some plant breeders, *ex situ* conservation of wild species biodiversity remains very marginalized (Saidi et al., 2007).

Table 16. Number of accessions maintained in the Settat gene bank by genus

Genus	Entry	%	Genus	Entry	%
Triticum	36104	66.82	*Astragalus*	141	0.26
Hordeum	3939	7.29	*Lathyrus*	141	0.26
Medicago	3388	6.27	*Festuca*	129	0.24
Avena	2133	3.95	*Dactylis*	124	0.23
Zea	1110	2.05	*Aegilops*	114	0.21
Helianthus	1004	1.86	*Trigonella*	95	0.18
Vicia	817	1.51	*Pisum*	71	0.13
Oryza	750	1.39	*Phalaris*	68	0.13
Cucumis	621	1.15	*Hippocrepis*	66	0.12
Trifolium	513	0.95	*Lotus*	66	0.12
Lens	367	0.68	*Linum*	52	0.1
Cicer	341	0.63	*Lolium*	47	0.09
Lupinus	302	0.56	*Melilotus*	45	0.08
Gossypium	259	0.48	*Coronilla*	44	0.08
Scorpiurus	251	0.46	*Anthyllis*	37	0.07
Carthamus	186	0.34	Other genera	542	1
Sorghum	161	0.3	Total	54028	-

Source: Ouabbou at al. (2016).

According to Heywood (2015b), Morocco has 4 botanic gardens in the Mediterranean climate zone. The main botanic gardens are a) the botanic garden of the Institut Scientifique, b) the botanic garden of the IAV Hassan II, c) the Jardin d'Essais Botaniques, and d) the exotic gardens of Bouknadel. Since the initial project in 1987, the city of Fès has not yet seen the official inauguration of its garden. All of these gardens include

environmental education and the conservation of native and endangered plants of Morocco among their objectives. Unfortunately, the precise number of living accessions in these gardens is unknown. Some estimations advance the number of 10,000. The same knowledge gap applies to the number of taxa held in these gardens with estimations between 1,000 and 2,000.

Created in 1950, the botanic garden of the Institut Scientifique is the most important botanic garden in Morocco. The garden has a herbarium with approximatively 150,000 specimens. Apparently, the garden and its collections are no longer actively managed. Number of taxa estimated at 1,200 with some rare & threatened plants of Morocco. In 1990, the botanic garden project of the Institut Agronomique et Véterinaire Hassan II was initiated but the actual botanic garden was established in 1997. The number of specimens in the herbarium as well as the number of taxa are unknown. Some native plants and some threatened species of Morocco are present in an ecological garden (Rejdali, 1998).

It is worth noting that specimens collected in Morocco are held in a wide range of herbaria, particularly in Europe. As reported by Ait Lafkih et al. (1993), an examination of 12 British and Irish herbaria for Moroccan specimens using a sample of the Apiaceae family (Umbelliferae) to record the number of specimens for each species and their collectors. According to the same source, the examined sample revealed 124 collectors and 1726 herbarium specimens representing 130 species compared with the 155 enumerated in Jahandiez & Maire (1931-1934) and Emberger & Maire (1941), (Ait Lafkih et al. 1993). Most importantly, the study presents the distribution of specimens by herbarium and the results of an extrapolation of the Apiaceae figures to all families of Morocco's flora. The authors suggest that that there may be as many as 38.540 specimens in Britain and Ireland with the Natural History Museum containing over 15.200 (Ait Lafkih et al., 1993). According to García-Sánchez & Cabezudo (2013), the herbarium of the University of Malaga (Spain) holds over 76.000 specimens of which 2.17% are from Northern Morocco.

The Jardin d'Essais Botaniques-Rabat opened officially in 1928 as an experimental garden undertaking trials on fruit trees and ornamental

species (Heywood, 2015b). After a period of disrepair, the garden was subject to a restoration with a broader remit including the conservation of Moroccan endemic species (Heywood, 2015b). The garden is home to more than 650 ornamental and fruit species of various origins: local, tropical, subtropical and desert. The garden arboretum alone contains a large genetic diversity consisting of 44 species belonging to 27 families. The garden is considered the precursor of the development of Moroccan fruit trees, especially of exotic origins. Its floristic richness contributes to the enrichment of national and global plant genetic resources. In 2012, UNESCO recognized the garden as a World Heritage Site (Heywood, 2015b). Established in 1952, the exotic gardens of Bouknadel-Salé have a herbarium of approximately 1,500 specimens. The numbers of taxa and rare and threatened plant species present in these gardens are unknown.

According to the second Country report on plant genetic resources for food and agriculture, Morocco has a national network of 40 arboreta to test the behavior of indigenous and exotic species established since the 1940s, while seed stands for 11 species and 114 stands are maintained *ex situ* (Saidi et al., 2007). Managed by the Forestry Department, the largest Arboretum is located in Oued Cherrat containing collections of *Agathis*, *Araucaria*, *Callitris*, *Cupressus*, *Juniperus*, *Pinus*, *Acacia*, *Albizzia*, *Bauhinia*, *Callistemon*, *Casuarina*, *Fraxinus*, *Melaleuca*, *Populus*, *Prosopis*, *Quercus*, and *Eucalyptus*. The Arboretum of Izarèn, west of Ouezzane (near Mokrisset) contains collections of *Abies*, *Callitris*, *Cupressus*, *Pinus*, *Acacia*, *Gleditschia*, and *Eucalyptus*. Other smaller arboreta contain collections of *Pinus*, *Cupressus* and *Eucalyptus* (https://www.cbd.int/doc/world/ma/ma-ex-bg-en.doc).

Heywood (2011) argues that botanic gardens will have an unprecedented opportunity to regain their role as introduction centres in response to global changes, particularly demographic and climatic change. The author identifies several opportunities for botanic gardens including the assessment of new germplasm for adaptation to climate change, the assessment of the likely migration or survival of species, the demonstration and recommendation of best plants to grow in urban and periurban sites (Heywood, 2011).

PART III: OPPORTUNITIES

What Does Morocco's Plant Diversity Offer to the Country and to the World?

Despite the great richness of Morocco's plant diversity, the numbers of plants currently exploited for food, medicinal use, forage, and other used are far below the potential of the flora. Menioui et al. (2013) reported a list of 57 plant species most exploited in Morocco. Listed species consist mainly of phanerophytes and chamephytes with the exception of two species of lower plants: a red alga sesquipedale giving the agar-agar and a hypogean mushroom, the famous "terfès" a Moroccan name for several species belonging to several genera. The selection of these species also took into account the information on useful plants available in specialized databases, in particular that of MEDUSA, which concerns plants useful in the Mediterranean Region.

From a flora, recognized as one of the richest in the Mediterranean Basin, with over 7000 taxa (vascular flora, fungi, and mosses included), only 57 species and subspecies directly useful to humans and/or considered of socio-economic importance. This implies that there are good opportunities for new and/or revisited plant uses in Morocco and/or elsewhere from prevailing plant diversity.

One of the most important features of Moroccan flora is the diversity of possibilities offered for use and exploitation. Plant diversity offers a valuable pool of genetic resources, a pool for discovering new medicinal drugs, a pool for identifying unconventional sources of healthier food, a pool for well-being products, a pool for better landscaping our surrounding environments, etc. Currently, plants provide forage for the Country's millions of livestock, food for an increasing population, medicinal herbs for primary health care for a large portion of Moroccan people, firewood for rural communities and people in mountains, materials for construction, crafts, ornaments in home gardens and city parks.

In the context of this chapter, only few key areas are used to illustrate the importance of plant diversity in the present and the potential for future

use nationally and internationally. Illustrative areas include medicinal plants, ornamentals, wild food plants, and genetic resources.

Bioactive Compounds Yet to Be Discovered from Moroccan Endemic Medicinal Herbs

The number of medicinal plants in Morocco varies across bibliographic sources. In his article on medicinal plants contributed to Morocco's Encyclopedia, Bellakhdar (1987) wrote that 'Of the few thousand plant species that form the Moroccan flora, the number of medicinal and aromatic plants economically exploitable could be estimated at approximately 500. Of the latter, only fifty are currently exploited in artisanal and marginal conditions in terms of modern production, development and marketing (translation by authors)." Birouk et al. (1995) suggested that the number of medicinal plants in Morocco is around 400. According to Rejdali (1996), about 600 plant species have been qualified as medicinal plants in Morocco, but a lot remains to be discovered. In his book on Medicinal plants of Morocco, Hmamouchi (1999) provided briefs on 340 plants. Bellakhdar (1997) provides a comprehensive account of the multiple uses of existing plants in traditional pharmacopeia. Local and regional ethnobotanical studies are increasingly uncovering the diversity and the rich use of medicinal plants of Morocco.

Morocco has a very rich tradition of using medicinal plants in primary health care and that tradition is still strong and alive until today (Bellakhdar, 1997). Moroccan people in different regions of the Country use locally available medicinal plants, resort to local souks, or herbalists to obtain needed plant materials. As reported in some studies, the frequency of use, the number of species, the number of diseases and health problems treated with plants are rather high. Moreover, along this traditional medicine, Mediterranean plants including those occurring in Morocco have been exploited in the development of modern pharmaceutical drugs.

As emphasized by Cuttelod et al., (2008) "North African people have ancient and rich traditions associated with the use of medicinal plants.

Plant-derived products are used in the production of traditional medicines, cosmetics and perfumes. They are particularly important for people of the region, as they are sometimes the only source of medicine readily available. Mediterranean plants have been used in the development of modern pharmaceutical products and crop varieties, and about 70% of the North African wild plants in the Mediterranean are known to be of potential value in fields such as medicine, biotechnology and crop improvements. Increased demand, coupled with unsustainable collection from the wild has led a number of important plant species to become scarce in areas where they were previously abundant. The regulation of their collection is therefore essential, to ensure that these valuable species continue to be available in future." As suggested by the World Health Organization (WHO), medicinal plants are the best source to obtain a wide range of drugs (anticancer, antidiabetic and antimicrobial compounds). According to the WHO, about 80% of people from developing countries depend on traditional medicine as source of primary health care. If plants are sources of some of the currently most important drugs, they definitely can be sources of potential new drugs.

In Morocco, medicinal plants from the wild contribute significantly to primary health care. The use of medicinal plants is rich, diverse, significant, and increasing. Local and regional ethnobotanical studies are necessary to document local knowledge but they are insufficient if not accompanied with scientific evidence contributing to shed light on the active compounds behind the presumed actions and effects of used medicinal plants. Chemical analyses should not lag behind ethnobotanical analyses. They are necessary for the understanding of the claimed medicinal properties or actions and for a safer and more efficient use of these properties. Scientific evidence on the chemical constituents of plants is key for the development of more complex drugs and products. Despite the increasing number of published articles on chemical analysis of medicinal plants in Morocco, the research domain is still weak considering the potential number of plants in need of solid scientific research especially among the endemics where Morocco can have the advantage of working

on plants not found elsewhere and thus contributing to the rest of the world.

In Morocco, *Lamiaceae* counts over 250 taxa of which 115 are national endemics (Dobignard & Chatelain, 2012). The richest genera in endemics are *Teucrium*, *Marrubium*, *Thymus*, and *Lavandula*. Most of these plants constitute potential sources of bioactivities and chemical compounds and thus need screening and rigorous analyses to uncover their constituents. Currently, only few *Lamiaceae* species have benefited from such scientific efforts, the results are promising and the opportunities are enormous especially for endemic species.

El Bouzidi et al. (2013) studied the chemical composition, antioxidant and antimicrobial activities of essential oil obtained from wild and cultivated Moroccan *Thymus* species. One of the main highlights of the study is that oils obtained from wild and cultivated species showed biological activity. In another study, Jamali et al. (2012) studied the chemical composition, antioxidant and anticandidal activities of essential oils from different wild Moroccan *Thymus* species. Kasrati et al. (2014) studied the antioxidative activity and synergetic effect of *Thymus saturejoides* essential oils with cefixime against selected food-borne bacteria. The highlights of the study showed that Carvacrol levels are higher and the best bioactivity and synergistic effects with cefixime are observed in the oil from Rich population (arid site-Midelt province). Chraibi et al. (2016) studied *Thymus satureioides* and *Mentha pulegium* essential oils, the plant material for the first species collected from Ijoukak (High Atlas), and the plant material for *Mentha pulegium* collected from Oued Laou. As clearly stated by the authors "Moroccan medicinal plants have great potential to be used as anti-tuberculosis agents. These findings may help scientists to undertake several research projects to discover useful natural product as new anti-tuberculosis drug" (Chraibi et al., 2016). The results of a recent study on antibacterial activity of essential oils of some Moroccan aromatic herbs against selected food-related bacteria showed that most essential oils were effective but *Thymus saturejoides* showed the greatest effectiveness (El Abdouni Khayari et al., 2016).

The *Teucrium* genus (*Lamiaceae*) is used as an example of the shortcomings in current research on medicinal plants in Morocco and the opportunities available for new discoveries. According to Dobignard and Chatelain (2012), the *Teucrium* genus is represented in Morocco by 59 taxa (species and subspecies) of which over half (35 taxa) are national endemics, that is an endemic rate of 59%. However, Moroccan ethnobotanical studies reported the use of *Teucrium polium* and very few other *Teucrium* species to treat a wide variety of health problems. Chemical studies on Moroccan *Teucrium* plants are lacking except for one recent study on the chemical composition of the national endemic *Teucrium antiatlanticum* (Kartah et al., 2015). The main conclusion of the study was that the essential oil of *Teucrium antiatlanticum* possessed a high content of sesquiterpene hydrocarbons. The study suggests that the results have ecological and economic significance for the possible utilization of the species in medicinal, cosmetic and chemical industries (Kartah et al., 2015). Moreover, there is a great regional difference in the composition and antibacterial activity of Morocco's medicinal plants according to their provenance. A study on Moroccan rosemary from four provenances showed that antibacterial activity of essential oils of rosemary is highest from the Sefrou region and lowest from Agadir region for all three strains used (Megzari et al., 2015).

There is an urgent need to learn more about Morocco's medicinal plants and tackle their chemical analysis especially that the international research is increasingly available to help with comparative research and knowledge improvement. There are more opportunities from the Country's medicinal plants than the current export of fresh and dried leaves and at best essence oils. Morocco's *Lamiaceae* family with about 250 taxa is rich in medicinal plants but frequently exploited through traditional local uses or destined to exports in fresh and dried forms. For *Rosmarinus* sp., the annual harvested quantity amounts to 20 000 tonnes of fresh plants allowing the extraction of about 60 tonnes of essential oils. It is worth noting that most exported medicinal herbs are collected from the wild. It is true that essential oils provide Morocco with foreign currency through export but the value is still low given the effects on the environment

resulting from overharvesting and uncontrolled exploitation. The investment in scientific research for better valorization of the Country's medicinal plants will have higher returns in the medium and long run.

There is an increasing national and international demand on natural products, herbal teas, and functional food products. Morocco's plant diversity can contribute to the satisfaction of this demand if the plant diversity opportunity is exploited properly through solid scientific research and sustainable use initiatives. The reliance on traditional use for export of dried plants are doing more harms than benefits to the plant national heritage. Unsustainable collection from the wild and overharvesting of particular species is only an example. A number of important plant species are becoming scarce in areas where they were previously abundant. The regulation of their collection is therefore essential, to ensure that these valuable species continue to be available in future.

During the recent years, aware of the fragmented nature of research and development activities on medicinal and aromatic plants in Morocco, the government achieved two major steps that eventually will help in the exploration of existing opportunities. These are the development of the National Strategy on Medicinal and Aromatic Plants and the establishment of the National Agency for Medicinal and Aromatic Plants. As clearly stated, one objective of the strategy is the provision of enabling conditions and factors for the success of Morocco's aromatic and medicinal plants sector and the development of significant domestic and international market shares. More precisely the objective is to enable the sector to shift from being a supplier of raw materials to a genuinely industrial sector offering a range of high added-value products for both domestic and international markets. The sector development, and even its survival, is linked to its evolution from rudimentary to industrial stage' (MAPM-HCEFLCD-USAID, 2008). Over the period 2011-2015, a biodiversity mainstreaming project is implemented in Morocco as part of the national strategy for aromatic and medicinal plants. The report on the final evaluation of the project states, "the overall objective is to encourage a sustainable production and a better valorization of spontaneous medicinal and aromatic plants through the sound management of natural resources,

biodiversity conservation, and capacity building of the different stakeholders in the value chains (PNUD-Maroc, 2015).

At last, Morocco established the National Agency for Medicinal and Aromatic Plants. The Agency replaces and takes seat in the headquarters of The National Institute of Medicinal and Aromatic Plants in Taounate established by the decree n°. 2-01-1836 of June 4, 2002, transformed into a public institution known as the National Agency for Medicinal and Aromatic Plants with the Dahir n° 1-15-04 of February 19, 2015 and by Law n° 111-12 (Bulletin Officiel n° 6344 of March 19, 2015) and put into application through the decree n° 2-15-305 of June 18, 2015 (Bulletin Officiel n° 6374 of July 2nd, 2015.

Article 3 of the Law states that the Agency's mission includes scientific research, development and innovation in the field of medicinal and aromatic plants and natural products and their valorization. The Agency shall also play a coordinating role between institutions and other public bodies concerned with medicinal and aromatic plants. More specifically, the Agency is responsible for the following, among others:

- Develop and implement research, innovation and technological development programs in relation to medicinal and aromatic plants in accordance with the choices and priorities set by the Government,
- Carry out scientific research and development and studies and all trials and works pertaining to medicinal and aromatic plants and their derivatives and those aimed at the deepening of the knowledge concerning these plants and their valorisation,
- Develop and update a referential for medicinal and aromatic plants,
- Create a national referential database of medicinal and aromatic plants,
- Contribute to the creation of business incubators in the field of medicinal and aromatic plants, in partnership, where appropriate, with other relevant national bodies,

- Coordinate, at national level, scientific activities related to medicinal and aromatic plants with other actors,
- Carry out scientific expertise, on request, for the benefit of public and private persons and the commercialization of the results of its research, studies and works, and
- Provide services to operators in the field of scientific and technological research through supervision, awareness raising and contribution to the improvement of the value of scientific research results and their transfer.

More importantly, Article 10 stipulates the creation of a Scientific Council within the Agency to deal with scientific matters related to the activities of the Agency.

Unfortunately, Morocco's research on medicinal plants suffers from fragmentation and lack of syntheses. Results are often attained through limited temporal and spatial research activities associated with university degree programs and /or short-term projects. Until today, Bellakhdar (1997) remains the only comprehensive and well-documented work on medicinal plants in Morocco.

Ornamental Plants: Towards a Better Balance between Exotic and Native Plants

In Morocco, compared with forages, medicinal and food plants, ornamental plants are the least known and least studied. In the absence of studies on ornamentals in the Country, this section is based on the authors' observations of cities public gardens and home gardens and the discussion with informants such as gardeners in public gardens, vendors in plant nurseries and flower markets. Most of Morocco's cities are embellished with exotic trees. *Jacaranda mimosifolia*, *Erythrina caffra*, *Brachychitum* sp., *Melia azedarach*, *Schinus molle*, *Ficus* sp., and *Araucaria* sp. have almost acquired symbolic value in particular cities. *Schinus molle* tends to be very common as an alignment tree not only in cities but also on roads

between cities and towns. Interestingly, all these trees are known with their common names in French and only few have been attributed Moroccan vernaculars often derived from a deviation of their common name such as rocaria, jacaranda, sinous, and loutrina.

The occurrence of *Ceratonia siliqua*, *Olea europaea* and other native trees is rather rare in comparison with the previous tree species. In Morocco's CBD Clearing House Mechanism, it is stated "The plants of our gardens and avenues are almost all exotic species. The unfortunate absence of indigenous species can be explained by the ignorance of the floristic potentialities of Morocco by both amateurs and decision-makers" (http://ma.chm-cbd.net/biodiversity/res_genetic).

The national study on biodiversity identifies several genera as precursors for ornamental plants found in the wild in Morocco. These include *Allium*, *Anemone*, *Centaurea*, *Cistus*, *Colchicum*, *Crocus*, *Cyclamen*, *Dianthus*, *Erianthus*, *Iris*, *Lilium*, *Myrtus*, *Narcissus*, *Nerium*, *Retama*, *Rosa* and *Silene* (MATUHE, 2001).

Morocco's plant diversity holds great possibilities for use as ornamentals if we consider the following two elements. First, the number of plant families suitable for ornamental purposes is important. These include *Asclepiadaceae*, *Crassulaceae*, *Ranunculaceae*, *Rosaceae*, *Iridaceae*, *Amaryllidaceae*, and *Liliaceae*. Endemic species within these families are important. For instance, Morocco's endemic *Narcissus* species are among the most beautiful plants. Endemic *Rothandemum* species, commonly referred to as Moroccan daisies, provide attractive flowers. Most of these plants can be grown as ornamentals in home gardens as well as in cities' green spaces if made available with needed information for successful growth. Unfortunately, no such materials is available and research on native ornamental plants, their growth requirements and their adaptation capacities is still lacking.

In an interview with Duncan (a South African native landscape architect and garden designer, living and working in Morocco for over 20 years), by Jeanette Lowdon, March 18, 2012 in Marrakech, Duncan was asked how has she educated the nurserymen in plant choices? Duncan responded that 'the nursery industry in Morocco has developed a lot in the

last 20 years, but there is still a long way to go. It is ironic that many indigenous plant species are not available in cultivation for landscape use. After slowly hammering away at growers, and with the growth of demand, we are starting to see local species being cultivated for sale as landscape plants." (http://moroccotravelblog.com/2012/03/18/cary-duncan-moroccos-leading-landscape-architect-garden-designer-your-morocco-travel-guide/).

Second, a quick glimpse at some of the historical gardens of Morocco attests to the splendor of ancient practices of mixing citrus, olive, and pomegranate trees with *Rosa* and *Geranium* shrubs. Many native trees, shrubs, and herbaceous plants can be used as ornamentals but need to be cultivated and prepared for the market. Exotic trees introduced in public gardens are nice but not to the point of obscuring local particularities of native tree species (Citrus, Olive, Carob). Historic gardens exemplify the balance between native and exotic trees such as the presence of *Casuarina* sp.in Jnan Sbil in Fès, *Platanus* sp. in front of the Museum in the Kasba Oudaya. The recent rehabilitation of these gardens while conserving their original structure is in itself a measure of preservation of Morocco's plant diversity and a case show for the potential use of native plants as ornamentals. Their historical value should be a learning lesson for plant amateurs as well as professionals in charge of green spaces and public gardens in urban Morocco. Boxes 2 through 6 provide synopsis descriptions of a variety of gardens from Moroccan cities.

Box 2: Jnan Sbil – Fès

Created in the 18th century, over 7.5 hectares in the heart of Fès, Jnan Sbil is one of the oldest and most prestigious gardens in the city. As part of the restoration process of historical monuments and sites realized by the Foundation for Environmental Protection, Jnan Sbil underwent a four -year restoration operation in 2006 to re-open in June 2010. Because of its historical significance, the restoration agency remained respectful of Jnan Sbil's original design and heirloom plants with the central tree lined alley, the bamboo garden, the *Washingtonia* sp. path, citrus and pomegranate trees.

Box 3: Agdal gardens – Marrakech

The twelfth century Agdal gardens are located within the grounds of the Royal Palace in Marrakech. The walkways throughout the gardens are lined with olive trees, and the orchards that include rows of pomegranate, orange, apricot, fig and lemon trees. The apricot orchards are especially fascinating, as they were originally planted on an elevated plot that can still be seen today. The ancient design and engineering feats that can still be marveled at makes a visit to the Agdal Gardens a very special and captivating experience. Green spaces have always been an integral part of life in Marrakech. In addition, the people of Marrakech have the traditions of picnicking in the city's gardens during the hot summer months.

Box 4: Kasbah Oudaya gardens - Rabat

Located at the mouth of the Bou Regreg river opposite of Salé, Kasba Oudaya was the citadel of Alhmohads, Merinids and subsequent Andalusians in Rabat since the twelfth century. The gardens are reflective of the Andalusian style with lines of red hibiscus, hedges, morning glories, date palms and orange trees with a long harbored walkway covered in grape vines. Although true to Andalusian traditions, with flowering annuals and beds of shrubs, the gardens were actually constructed by the French in the twentieth-century. The gardens are a shady retreat, with a profusion of daturas, oleanders, orange, lemon and banana trees.

Box 5: Exotic gardens of Bouknadel – Salé

Located in the territorial district of Bouknadel, created by Marcel Francois in 1951 and open to the public ten years later. Recently, the Gardens underwent a four-year restoration process financed by the Foundation Mohamed VI for Environmental Protection of Morocco's heritage sites. The restoration remained faithful to the gardens authentic design and splendor of the time of their creation with bridges, paths and a wide variety of exotic trees and plants.

Box 6: Majorelle gardens - Marrakech

In 1998, Benchaabane, on behalf of Yves St. Laurent and Pierre Berger, the owners of the Majorelle Gardens in Marrakech, surveyed existing plants and provided their Latin names as part of the restoration of the gardens to honor Jacques Majorelle who created them. Benchaabane catalogued 120 plant species and added new ones from the gardens' existing plant families, raising the total grown in the garden to 325. Currently, Benchaabane acts as director of the charitable trust set up to protect the Majorelle Gardens.

One of the striking features regarding the potential use of national plant diversity to draw interesting plant species is the lack of research and documentation. With the exception of nurseries inclined to produce and sell exotic flowers and exotic plants, the whole sector is entirely overlooked. Ornamentals can provide an interesting niche offering jobs and income earning opportunities for private plants nurseries, flowers sales, landscaping agencies and many other opportunities. The demand is rather increasing because of the improvement of standard of living in Morocco. Local governments are increasingly interested in landscaping and embellishing public spaces in their territorial localities. Private enterprises need to develop innovative initiatives and decision makers in charge of green spaces and landscaping need to rethink their modus operandi of importing flowers. According to informants, sometimes, even temporary flowers used for seasonal landscaping purposes are imported.

Food Plants: Cultivated and Wild Food Plants, Food Additives, Condiments

Plants are definitely a major source of food in Morocco. Cultivated cereals, food legumes, fruit trees, and vegetables are only examples of the vital role of plants in the provision of food for Moroccan population. In addition, Moroccan people in general, and inhabitants of particular regions, commonly complement their nutritional intake by seasonal consumption of wild food plants. Nassif and Tanji (2013a) listed 246 spontaneous plants

used in Morocco as sources of food in different regions of Morocco. Seasonal use of wild food plants is frequent throughout Morocco. This use is more significant in particular mountain villages of the Middle Atlas and rural communities in the North of Morocco (Nassif and Tanji, 2013b). Seasonal and year around sales of *Portulaca*, *Malva*, and *Beta* species in local souks, or particular places in the cities, are indicative of common use of these plants. The authors concluded that gathered food plants related knowledge and traditions are at risk of erosion. Thus, it is not only necessary to document wild food associated knowledge but the study of wild food plants can help uncover opportunities for the use of these plants in the future" (Nassif and Tanji, 2013a).

Historically, plants were instrumental in helping people overcome famine episodes in Morocco (Nassif and Tanji, 2013c). A study on the use of wild plants during severe droughts and food shortages, a list of 54 plant species was compiled (Nassif and Tanji, 2013c). Examples of these plants include *Arisarum* sp., *Arum* sp., *Bunium* sp., *Eryngium* sp., and *Quercus* sp. The authors noted that while nature offered an array of plants, it was women's extraordinary ingenuity responsible for processing these plants into food. Extremely tiny seeds and tubers were prepared through long multi-stage operations to be rolled into couscous or knead for making bread (Nassif and Tanji, 2013c). The article concluded that knowing plants used during famines and food shortages and understanding their role in saving people's lives are crucial to valuing Morocco's biological and cultural diversity. Not only is this understanding necessary for preserving plant diversity but it is also needed for demystifying the stigma associated with some plants for present and future generations (Nassif and Tanji, 2013c).

In Morocco, the popular phrase '*makla wa dwa*' that translates into 'food and medicine' is frequently used by people particularly in rural areas in relation to some plant species such as *Thymus*, *Asparagus*, and *Allium*. With frequent radio and television programs on nutrition, medicinal plants, healthy food, there is an increasing awareness among common people about plants and their role in health maintenance. Many women in a rural village in Oued Zem region made comparisons between cultivated spinach

and *Beta macrocarpa* collected from the wild. One woman recognized having eaten the plant to treat anemia after a visit to a medical doctor who told her she has anemia.

Crop Wild Relatives: An Insurance for the Third Millennium

Plant genetic resources for food and agriculture (PGRFA) are the biological basis of world food security and, directly or indirectly support the livelihood of every person on earth (FAO, 1998). As a key component of overall biodiversity, plant genetic resources are necessary for providing food, supporting livelihoods, and for contributing to economic development in rather significant ways. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture suggests that plant genetic diversity continues to play a vital role in shaping agriculture growth in the face of climate change and other environmental challenges (FAO, 2010).

Aware of the importance of plant genetic resources and their link to sustainable development, the National Committee of Plant Genetic Resources organized a national seminar on this topic in 1996 in Rabat. The proceedings of the seminar provide an updated information on the state of Morocco's PGR at the time, relevant issues and recommendations (Birouk & Rejdali, 1997).

Recently, there has been a growing documentation on the potentially negative impacts of climate change coupled with the world population growth on global food security. A good exploitation of crop wild relatives (CWR) is considered the likely best option to face these threats (Maxted & Kell, 2009; Vincent et al., 2013; Castañeda-Álvarez et al., 2016). The commonly used definition of CWR refers to wild species that are relatively closely related to agricultural and horticultural crops. Maxted and Kell (2009) argue that this definition is too broad and therefore leads to the inclusion of large numbers of species. There is an urgent need to narrow the definition of CWR so that limited conservation resources can be focused on priority species either those most closely related to the crop or those known to have traits required by breeders. Maxted & Kell (2009)

proposed a definition stating that ‘a crop wild relative is a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop; this relationship is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the crop’.

As part of the Mediterranean Basin, historically known as an important pool for crop wild relatives, Morocco is home of a significant number of crop wild relatives. According to Vincent et al. (2013) and based on the unit area per CWR instead of numbers of CWR, Morocco is ranked 13th out of 25 countries with total priority CWR exceeding 80 (Table 17).

Table 17. Numbers of crop wild relatives per country where total priority CWR is above 80

Country	Total priority CWR	Unit area per CWR (km^2)
Lebanon	97	108
Israel	98	225
Albania	81	355
Armenia	81	367
Azerbaijan	91	952
Greece	134	985
Portugal	91	1012
Bulgaria	96	1155
Syria	112	1653
Italy	139	2168
Spain	132	3833
Turkey	189	4146
Morocco	99	4511
Iraq	90	4836
France	111	5768
Ukraine	86	7017
Iran	131	12,582
Peru	96	13,388
Mexico	109	18,022
Indonesia	84	22,749
Algeria	96	24,810
India	123	26,726
China	221	43,620
USA	152	63,349
Russia	117	145,942

Source: Vincent et al., 2013.

The global strategy for the *ex situ* conservation of oats (*Avena* sp.) reports that the greatest number of biological species occurs in North Africa, Southern Spain and Sicily. More precisely, Tetraploid species, which form the secondary gene pool, are mostly restricted in distribution and rare in nature and in collections. They occur in Algeria, Morocco, Tunisia, Spain and Sicily (Germeier, 2008). According to the same source, the collection of INRA Morocco is the most important collection in the Centre of diversity for the wild Avena species and holds many rare and endemic species (Germeier, 2008). The strategy suggests that both important collections in the centre of diversity, the Moroccan and the Spanish collection are in urgent need of regeneration (Germeier, 2008).

The International Center for Agricultural Research in the Dry Areas (ICARDA) was commissioned by Global Crop Diversity Trust to coordinate the development of the Global Strategy for the *ex situ* conservation and use of barley germplasm. With 3743 accessions, the INRA Morocco collection is reported as one of the 47 major barley collections (ICARDA, 2008). About 67% of the collections is of national origin. In addition, Morocco's barley collections comprises a significant proportion of indigenous landraces materials (ICARDA, 2008).

In 2012, Morocco contributed 351 wheat accessions (195 *Triticum durum* and 156 *Triticum aestivum*) to the gene pool of the International Treaty on Plant Genetic Resources for Food and Agriculture. Evaluated during the life of a Benefit-sharing Fund project implemented in Morocco, these wheat accessions can now be shared through the Standard Material Transfer Agreement. As clearly stated by the Secretary of the International Treaty, "This work goes beyond regular conservation of genetic diversity, as we know that some of this genetic material will contribute to the global efforts against the UG99, a fungus that attacks wheat and that has caused serious production losses in Africa and the Middle East for more than a decade," http://www.fao.org/plant-treaty/news/detail-events/en/c/341478/.

Morocco is part of the international ten-year Project "Adapting agriculture to climate change: collecting, protecting and preparing crop wild relatives" launched in 2011. Implemented in various parts of the world, this project is jointly led and managed by the Global Crop Diversity

Trust (Crop Trust) with the Royal Botanic Gardens, Kew. The rationale for the project includes three major elements.

First, crop wild relatives contain genes of potential value for plant breeding, among which traits of relevance to climate change adaptation. Crop wild relatives 'can contribute to climate change adaptation when they possess a trait that has the potential to help crops become more resilient and adaptive under the changing environmental conditions projected under climate change'.

Second, 'traits and genes of crop wild relatives can help agriculture respond to some of the threats posed by climate change. Crop wild relatives provide the opportunity to improve the productivity and resilience of agriculture. However, in the coming century, as population increases to over 9 billion and climate change intensifies, exacerbating the spread of crop pests and diseases, they may become indispensable'.

Third, crop wild relatives today face a number of threats including changes in land use, intensification of agriculture, overgrazing, and climate change. We have to make sure that valuable genetic diversity of crop wild relatives is not lost forever. This can be done *ex situ*, in gene bank collections, and *in situ*, by protecting wild and semi wild populations where they occur'. The four main activities supported by the project are a) prioritization of Crop Wild Relatives, b) collecting, c) conservation, and d) pre-breeding for 20 of these'.

Morocco, in collaboration with ICARDA and several other partners, is conducting pre-breeding activities for grass pea (*Lathyrus sativus*), barley (*Hordeum vulgare*), durum wheat (*Triticum durum*), lentil (*Lens culinaris*), and chickpea (*Cicer arietinum*).

In sum, there is an increasing awareness about the possibilities associated with the national green heritage as long as it is respected, conserved and used sustainably. In the fifth national report to the CBD, it is suggested that conservation (objectives and measures) allows the creation of new capital flows and additional resources for sustainable use for the benefits of local users of this diversity. Examples of landraces, medicinal plants, genetic resources for use in cosmetics present an

underestimated potential for local development and health care that Morocco could develop further.

PART IV: CHALLENGES

The opportunities associated with plant diversity are pending on the Country's capability of successfully overcoming prevailing challenges. Three of these challenges are addressed here to provide insights on the magnitude and the complexity of work yet to be accomplished in the future. These include the following a) the mega challenge of development in Morocco, b) deficiencies and constrains in relevant research, and c) conservation and protection related challenges.

a) Development of All Morocco, Development for All Moroccans: A Prerequisite for Mitigating Threats on Plant Diversity

In Morocco, development related issues, namely poverty rates, human development, and urban-rural disparities need to be resolved otherwise, mountains, forests, and plants continue to be at risk of overexploitation and deterioration. This is the mega challenge that will condition how the other challenges are tackled. Without sustainable development for all Moroccans and throughout all of Morocco, it is difficult to expect effective progress in conserving plant diversity and adequate exploring of related opportunities. All Moroccan communities and people, particularly those in mountains and remote areas, need to have all year around accessible roads, schools for their children, hospitals for their sick and income generating opportunities for their active adults.

Despite all the efforts and achievements, Morocco still suffers from key development issues such as the high poverty rates, urban-rural disparities and low human development especially in rural communities. Rural Morocco in general and mountain areas in particular are the

territories that lag far behind. Urban rural disparities must be resolved and mountain communities need to benefit from equitable sustainable development opportunities. Mountain ecosystems and forests constitute the immediate environment for a significant share of Moroccan people. These same mountains are home of the Country's natural richness, biodiversity, flora and fauna, and the much-praised endemism.

As said before in this chapter, the Atlas and the Rif mountains are the home of national endemics. These same mountains are home of impoverished communities and people living in poverty. For example, the Aghbar rural commune has a poverty rate of 16.1%, a vulnerability rate of 28.8% and a Gini coefficient amounting to 25.5% (HCP, 2010). This is the territory where the SIBE for *Cupressus atlantica* occurs. Similar analogies prevail in several other rural communes where SIBEs, IPAs, and national parks are located. Table 18 presents selected indicators from recent reports and documents to illustrate the persistent urban–rural disparity.

National averages continue to blur a striking and quite visible reality in rural and mountain areas of Morocco. It is rather paradoxical, while these mountains are home of national endemic plants, rare species, Morocco's most valuable forests and emblematic trees; they host the poorest communities of the Country.

Regardless of the approach adopted or the poverty type, the differences between urban and rural areas persist and at times tend to be extremely high. In 2014, rates of multidimensional and absolute poverty in rural areas of Morocco are about ten times higher than those registered in urban areas (HCP, 2015). The fight against urban rural disparities is one of the main themes addressed in the national consultations held around the post 2015 development priorities (HCP, 2015).

In Morocco, mountains and their communities need to become a development priority not only for environmental reasons but also for social and equity reasons. Mountain communities and people need to receive their deserved share from the benefits of the Country's development and not welfare programs and initiatives. All the studies published on mountain

villages and people, regardless of their central theme confirm the vulnerability of the people and their living conditions (Nassif, 2009).

Table 18. Urban rural disparities in Morocco

Indicator	Reference year (Source)	Rural %	Urban %	National %
Absolute poverty rate (measured by the high national threshold established in 2014 in 4395 DH per person per year for city dwellers, and in 4266 DH for rural dwellers)	2014 (HCP, 2015)	8.9	1.1	4.2
Vulnerability rate	2014 (HCP, 2015)	18.4	6.9	11.5
Relative poverty (measured by 60% of the median consumer spending per capita)	2014 (HCP, 2015)	31.3	10.0	18.8
Multidimensional poverty (assessed by the UNDP adopted approach called the Oxford approach, or according to the Alkire-Foster approach)	2014 (HCP, 2015)	13.1	1.3	6.0
Subjective poverty	2014 (HCP, 2015)	49.0	37.9	42.3
Poverty rate based on national poverty line (%)	2008 (IMF, 2013 using HCP data)	14.4	4.7	8.8
Life expectancy at birth	2014 (Arab Development Portal, 2016)	71.7	77	74.3
Illiteracy (10 year +)	2011 (Boutayeb et al., 2012)	53.6	25.4	37.6
% of women who had prenatal care	2011 (Boutayeb et al., 2012)	62.7	91.6	77.1
% of deliveries in health services	2011 (Boutayeb et al., 2012)	54.6	90.7	72.7
% of assisted deliveries	2011 (Boutayeb et al., 2012)	55.0	92.1	73.6
% of women who had postnatal care	2011 (Boutayeb et al., 2012)	13.3	30.5	21.9

As pointed out in the Environmental Performance Review, illegal forest exploitation and illegal hunting are not primarily a consequence of lack of awareness, but they are driven by poverty and a lack of adequate socioeconomic alternatives (UNECE, 2014). Human development opportunities (schooling, health care, adequate infrastructure, work, alternative sources of energy) are not an option but an urgently must in mountains of the 21st century Morocco.

In the state of Mediterranean forest, it is argued that a country's situation is considered compatible with sustainable development if its human development indicator (HDI) is above 0.8 and its ecological footprint (EF) is less than 1.8 global hectares per capita (FAO, 2013). In 2007, no Mediterranean countries (and none globally) were in this "sustainable development" zone. HDI increased in all countries in the Mediterranean region between 1997 and 2007, but only two countries (Lebanon and Malta) significantly reduced their EFs per capita. The relatively low EFs (i.e., lower than the global average of 1.8 global hectares per capita) in Algeria, Egypt, Morocco and the Syrian Arab Republic are due mainly to constraints related to the arid climate in those countries. Their low HDIs reflect a high dependency on natural resources and significant levels of poverty (FAO, 2013).

As pointed out by Semlali (2010), "poverty and social inequalities have always been a constant characteristic of Morocco's social fabric. This phenomenon has grown significantly since the application of the Structural Adjustment Plans (SAPs) in the 1980s. A study carried out by the High Commission for Planning (HCP) for Morocco in 2007 showed that the national poverty rate was 9.0% (14.5% in rural areas, and 4.8% in urban areas)." The strangest paradox in Morocco is that poverty has been significantly reduced but urban rural disparities persist. Poverty was and still is a rural phenomenon. According to the Arab Development Portal, life expectancy at birth in Morocco increased from 68 years in 2000 to 74.3 years in 2015 but there is a gap of five years between rural and urban areas (77 years in urban and 72 years in rural areas), (http://arabdevelopment portal.com/country/morocco).

As noted by Achy (2010), "despite the amount of money allocated to social programs in Morocco, the assistance has failed to trickle down to the poorest segments of the population, and there are wide disparities within and among regions." The International Monetary Fund Country report states that poverty has considerably decreased in Morocco over the past decade. About 1.7 million people have moved out of poverty and the poverty rate has decreased by more than 40% (IMF, 2013). However, this significant decrease in poverty has not been accompanied by a similar improvement in inequality (IMF, 2013). Moreover, the report notes that inequality has slightly increased and remains persistently high in both urban and rural areas (IMF, 2013).

b) Solid Research the Only Way to Know, to Understand, to Value and to Protect Morocco's Plant Diversity

As noted in the introduction and throughout the paper, the whole story of plant diversity of Morocco is yet to be written. The last two decades have witnessed the publication of major books of national scope on Moroccan flora. This includes the inventory of rare, threatened or endemic vascular plants of Morocco (Fennane & Ibn Tattou, 1998), the three volumes of the practical flora of Morocco (Fennane et al., 1999, 2007, 2014), and the two volumes of the inventory of vascular plants of Morocco (Fennane & Ibn Tattou, 2005; Ibn Tattou & Fennane, 2008). The two volumes of vascular plants of Northern Morocco (Valdéz et al., 2002). Morocco's plant diversity needs solid constant research both bibliographic based and field investigations at the ecosystem-habitat and species levels. Prevailing knowledge gaps are rather significant and concern aspects such as the precise distribution of many species, particularly among the endemic and rare plants, the time series assessments of species, namely critically endangered ones. National endemic, rare and threatened species are the most information deficient. They tend to be the poorly known plants of Morocco.

During the past years, the Department of Environment conducted a study as part of the GEF/UNEP project "Development of the Information Exchange Center, Capacity Assessment for ABS and Taxonomy in Morocco." The study aimed at establishing the state of knowledge of the biological inventory, highlighting the extent of the taxonomic obstacle impeding efforts to conserve and manage biodiversity, identifying concrete ways to overcome these obstacles and proposing strategic orientations for a future national strategy' (Menioui et al., 2013).

Menioui et al., (2013) noted that among the taxa constituting Moroccan vascular flora, there are no less than 170 groups or aggregates that pose problems in terms of taxonomy and nomenclature. These include Pteridophyta (7 aggregates), Gymnospermae (4), Angiospermae dicotyledonae (169) and Angiospermae monocotyledonae (4 aggregates). The full list of these groups of the vascular plants with little or no study is reported in the annex 20 (Menioui et al., 2013). The authors clearly state that if the vascular flora is relatively well known, the cryptoflora is infinitely less so (Menioui et al., 2013). Moreover, Morocco lags far behind in identifying living resources for the purpose of valorization despite the vital importance of this biological component (agriculture, fishing, forestry, aromatic and medicinal plants) in socioeconomic development.

As pointed out, "One of the major problems for a better exploitation of Morocco's natural living resources is the lack of an integrated view of all populations/settlements/areas targeted by exploitation and an understanding of the links between different biotic compartments of these environments. Microorganisms remain the least known group among the main components of Moroccan biodiversity. Thus, if for many major taxa, more or less exhaustive lists are established, the information remains very fragmentary, too punctual and often difficult to access in the case of microorganisms" (Menioui et al., 2013). However, Morocco has signed and ratified a number of international agreements aimed at the rational management of living resources, including the CBD (Menioui et al., 2013).

In Morocco, taxonomy, essential to understanding the functioning of the habitats of these resources, to the management of natural resources and

the improvement of the welfare of the populations is not given priority (Menioui et al., 2013). The analysis of the various national biodiversity studies and the results of the interviews and workshops on taxonomy all seem unanimous on the seriously deficient national capacities for species descriptions (Menioui et al, 2013).

Morocco is also lagging behind other countries in terms of digitization, systematic inventories, and the national contribution to international biodiversity data-sharing initiatives (Menioui et al., 2013). All these shortcomings, and many others, constitute handicaps for the development and valorization of taxonomy and, at the same time, national biological resources. The current state of knowledge makes it extremely difficult to give an accurate list of human skills in taxonomic research, but it seems clear that human expertise is too insufficient to contribute effectively to improving knowledge about national biological diversity heritage, the exploitation of its resources and the socio-economic development of the country. Many taxa remain today unstudied or poorly investigated, and, therefore, less valued. The situation is even worse when one is interested in the parataxinomy of having technicians specialized in the identification of species of interest to the Country such as museology, control, and surveillance.

According to Menioui et al. (2013), "all indicators indicate that there are four main constraints affecting a coherent, harmonious and rewarding exercise of taxonomy in Morocco, 1) insufficient human resources, 2) lack of material and financial resources, 3) ignorance of the importance of taxonomy in economic and social terms, and 4) insufficient synergy between actors. The lack of resources and equipment is therefore a major handicap to the development of taxonomy in the Country. This lack concerns almost everything, from the field material to the drawing material of dissected pieces, going through everything that is necessary for the sampling, the conservation and the storage." Fennane (2008) clearly recognizes that no PhD level training in plant systematics exist in Morocco.

In his article on the past, present and future of floristic research in Morocco, Fennane (2008) suggests, "The floristic research in Morocco no

longer occupies the place it deserves. This article sets out very briefly their case. It is also a call to draw attention to a very worrying situation. Why this call? Now and in Prospective Universities? The answers are simple: 1) the stakes of floristic research are very important for our Country. Unfortunately, this research is currently not doing well and it is not necessarily for material reasons. 2) The current reform of research structures does not contribute to the improvement of an increasingly worrying situation. 3) The Mohammed V University–Agdal-Rabat is directly concerned by the problem, given its very important contribution through the Scientific Institute for the knowledge of the national flora."

Further, Fennane (2008) notes, "Our country needs more than ever botanic research sufficiently active to meet its internal requirements (information on the flora to better exploit it, enhance it, manage it, and protect it). Morocco also needs a scientific body for the accompaniment and follow-up of the actions implemented within the framework of its international commitments. The difficulties are great and the challenges are as important as our means and capacities, and chances of success exist. Unfortunately, the current situation does not augur well given the decline in the number of specialists and the lack of training for young people. Even more seriously, the structuring of current research does not include a plant system laboratory at the national level. The Department of Botany and Plant Ecology of the Scientific Institute is reduced to a research unit! This department which carried the torch of the floristic research in Morocco for almost a century is pushed to agony without any alternative for the Country."

Constant research updates with periodic field investigations are key to effective targeted conservation. As noted earlier, the first half of the twentieth century was a great era for botanic explorations in Morocco. The creation of the Scientific Institute in Rabat in 1922 contributed in a decisive way to the progress of floristic research and accumulated knowledge sufficient for the writing of the 'Catalogue des Plantes du Maroc' between 1931 and 1941 (Jahandiez & Maire, 1931-1934; Emberger & Maire, 1941).

One of the striking paradoxes in current botanic research in Morocco is the gap between the availability and widespread of new technologies (photography instruments, GPS, etc.), achieved progress in roads and means of transport, increased access to much of Morocco's territory compared to 70 years ago, and the lack of drive, interest, and public support for floristic research. At the present, most young researchers are only interested in getting their diplomas and finding a job. Scientific research qualities such as complete devotion, sacrifice, perseverance are no longer used currency. The Country's strategy of higher education is not helping. The voluntary departure program in 2005, retirement, and limited hiring are increasingly depleting research institutions from experienced human resources without adequate replacements. The main characteristics of Morocco's vascular flora and the gaps are known and the way to progress is clear. Unfortunately, Morocco's floristic research is declining and the worst is to be dreaded when we know that there is no training of young systematic botanists nowhere in the Country (Fennane & Ibn Tattou, 2012).

Plant diversity of Morocco needs a task force with adequate means. The few researchers of the Scientific Institute are expressing concerns loud and clear about the future of research and subsequently the future of plant diversity, plant conservation and sustainable use.

Regarding the research challenges at the ecosystem-habitat level, the existing SIBEs network in general and IPAs in particular are good building blocks for knowledge development about plant diversity. However, several SIBEs, especially of priority 2 and 3, are currently information deficient. Recently elaborated factsheets on the 19 IPAs in Morocco are not all endowed with sufficient information on species richness, taxonomic updates, species' updated status, uses, threats, appropriate conservation measures, and any other species level information. Good knowledge of the distribution and status of vital habitats necessary for the survival of particular species and the protection of these habitats through these protected areas against the different threats is necessary for the conservation of these species. National and international experts are increasingly pointing out knowledge gaps.

As noted in Morocco's Environmental Performance Review, despite the fact that Morocco has 68 key biodiversity areas forming part of the wider Mediterranean Basin biodiversity hotspot, of which two have been identified as being Irreplaceable Key Biodiversity Areas, various aspects of the biodiversity of Morocco remain uncertain (UNECE, 2014). This situation is due to several knowledge gaps such as gaps relating to specific species or groups, genetic resources, and ecosystems. Some SIBEs are losing their diversity in a rather significant manner because of inadequate research follow up. Box 7 presents a priority 1 level SIBE to illustrate this point.

Box 7: Essaouira Archipelago:
The loss of plant diversity in a priority 1 level SIBE – Ramsar site

The Essaouira Archipelago (4,000 ha) is a coastal site of biological and ecological interest of first priority (L25). The Archipelago is also known as the Mogador island consisting of two islands and several tiny islets. Not only is the archipelago unique on the Atlantic coast of Morocco, but it is home for threatened fauna (*Falco **Eleonorae***) and endemic flora.

The archipelago has been listed a hunting reserve in 1962, a permanent biological reserve in 1980, with surrounding sandy dunes as first prirority SIBEs in 1996 and registered as a Ramsar site in January 2005. Currently, the archipelago is included among the priority wetlands to be reclassed by 2020 based on the law n° 22-07 pertaining to protected areas.

Organized through a joint venture between the Forestry Department and the Conservatoire du littoral, a multidisciplinary team conducted three field visits in June, August, and September 2010 with the objective of strengthening the management dynamics on Site and its marine and terrestrial ecosystems.

The two main malfunctions noted by the team were the regular presence of people causing disturbance for the Island's nesting birds and the degradation of the vegetation caused by the population explosion of the Goéland bird (*Larus michahellis*).

From the botanic perspective of interest in this chapter, Ibn Tattou (2010), an experienced botanist, observed that the two features predominating the landscape were the significant presence of the Goeland bird and the monotony and uniformity of the vegetation cover. Woody shrubs of *Lycium intricatum*, *Bassia tomentosa*, *Salsola verticillata*, and *Suada vera* are juxstaposed with *Mesembryanthemum cristallinum*. *Atriplex parviflora* (*Amaranthaceae*) and *Poycarpaea nivea* (*Caryophyllaceae*) are present, often in tufts.

Ibn Tattou (2010) compared the situation observed in 2010 with the situation in1921 as described in Braun Blanquet & Maire (1924). The two main changes are the impoverishment of the floristic richness moving from 58 plant species inventoried in 1921 to only 18 species in 2010. The second change is the uniformisation of the vegetation cover. As pointed out by Ibn Tattou (2010), in 1921, Braun Blanquet & Maire (1924) described two major formations, one based on *Bassia tomentosa* with 16 taxa and the other based on *Andryala pinnatifida* with 27 taxa. In 2010, *Andryala pinnatifida*, which covered almost half the great island, has disappeared completely and *Bassia tomentosa* invaded the entire island.

In the Ecosystem Profile on Mediterranean Basin Biodiversity Hotspot submitted to the Critical Ecosystem Partnership Fund (CEPF) donor council, Essaouira dunes are not only included in the priority key biodiversity areas for CEPF investments but are also included in the list of irreplaceable key biodiversity areas (CEPF, 2010).

In an attempt to visit the Archipelago in April 2014, Nassif learned on ground that the island can no longer be visited without an official authorization.

Research needs keeping up with scientific revisions on families, genera, and species levels as scientific techniques evolve and knowledge of plants progress. Taxonomic updates, revised genus and family classifications, and precise geographic distributions of species are necessary. Recently published articles, particularly ethnobotanical, still contain botanic names that have been changed or totally rejected. Other articles continue mentioning names of plants declared extinct or absent from particular regions of Morocco.

c) The Challenge of Effectively Conserving and Protecting Morocco's Plant Diversity in General, Rare and/or Threatened Species in Particular

International Targets: Morocco Has a Long Way to Go

As noted earlier, the CBD Conference of the Parties, held in October 2010, in Nagoya (Japan), adopted a revised and updated Strategic Plan for Biodiversity, including the 20 Aichi Biodiversity Targets for the period 2011-2020. Although the plan is an overarching framework on biodiversity, not only for plant diversity, it provides a binding comparative framework for all countries and for the entire United Nations System. The Global Strategy for Plant Conservation, also adopted by the CBD in 2002 and updated in 2010 provides the global framework for plant conservation at national and global levels. Therefore, it is only logical to confront Morocco's situation in plant diversity conservation against the 16 GSPC targets and 20 Aichi targets.

Morocco's fourth report to the CBD (SECEE, 2009) includes an appendix on achieved progress towards the GSPC targets and working program on protected areas. The appendix states that there has been little progress since the third national report to the CBD (SECEE, 2009). Nevertheless, the appendix passed all 16 GSPC targets noting ongoing biodiversity related activities and the lack of national objectives for several targets. Reported achievements include the creation of the gene bank in Settat, the seed bank of wild plants in the Institut Scientifique in Rabat, the creation of Cedar biosphere reserve, and the recommendation of protecting around 1600 threatened plants.

In the executive summary of the fifth national report to the CBD (MDCE, 2014b), it is stated that Morocco's progress in implementing the 2011-2020 strategic plan and the Aichi objectives is at an early stage and that the new Strategy will be complemented by the Action Plan which is currently being revised. Within the framework of its sectoral policies, Morocco has taken initiatives that are in line with the Strategic Plan 2011-2020 and the Aichi objectives. Examples mentioned include the identification of Important Plant Areas, the inscription of 20 Ramsar sites,

the creation of the first intercontinental biosphere with Spain, the adoption of a Law CITES for the protection of threatened species (MDCE, 2014b).

As noted before, Morocco elaborated the first National Biodiversity Strategy and Action Plan (NBSAP) in 2004 and developed a revised and updated National Biodiversity Strategy and Action Plan (NBSAP 2016-2020) in 2014. The six strategic lines of the NBSAP 2016-2020 covered the following: a) protection, preservation, rehabilitation, b) sustainability of biological diversity, c) optimization of exploitation, d) governance improvement, e) knowledge improvement, and f) promoting behavioral changes (MDCE, 2014a).

With respect to Morocco's response to the Global Strategy on Plant Conservation, a focal point for the GSPC was nominated and a workshop on the GSPC was organized on March 31 & 01 April 2014 in Marrakech. The workshop focused on progress in implementation of the GSPC at global and national levels and the linkages between the GSPC and the Aichi Biodiversity targets. Several challenges for plant conservation in Morocco were raised including the difficult economic environment in recent years and the lack of taxonomic capacity. The two main suggestions of the workshops were a better coordination for activities pertaining to plant conservation and the establishment of a scientific committee to provide scientific advice to government and create a link between science and policy' (www.bgci.org/resources/news/1106/).

Not only is a national progress report on the implementation of GSPC absent, but the fourth national report (2009), the fifth national report (2014) to the CBD and the National Biodiversity Strategy and Action Plan 2016-2020 contain very limited mention of the GSPC and its targets. However, the Global Diversity Foundation (GDF) has provided a report consisting of review of progress on GSPC in Morocco (www.bgci.org/plants2020/document/0277).

The Foundation is conducting a series of projects and activities falling under the plant conservation umbrella. The GDF and collaborators have carried out projects in Imegdale (Al Haouz province) and Ait Mhamed (Azilal province) rural communes in the High Atlas. The Foundation website provides details on conducted projects, adopted approach,

achieved results, and collaborators (www.global-diversity.org/mediterranean).

Interestingly, the global CBD progress report on the implementation of the GSPC targets issued in 23 March 2016 draws its information on Morocco's progress from the Global Diversity Foundation's report. Achieved progress in Morocco is presented by target based essentially on the GBD report for covered targets and additional sources for non-covered targets (Targets 5, 6, 8, 9, 10, 11, 12, and 15).

The 16 targets for plant conservation to be achieved by 2020 are framed through the GSPC five objectives. As noted in the guide compiled by Sharrock (2012), while targets have been set globally, plant conservation activities are conducted at the national level and the implementation of targets is conducted within the context of National Biodiversity Strategies and Action Plans.

Plant Diversity Is Understood, Documented and Recognized

The first objective of the GSPC encompasses targets 1, 2 and 3. At this point, none of the three targets displays sufficient progress to expect their full achievement by 2020 in Morocco. The on-line accessibility and availability of all known plants of Morocco needs much more concerted efforts. The assessment of the conservation status of all known plant species of the Country for setting priorities and guiding conservation actions is not in better situation than the first target. Target 3 focusing on the development and sharing of information, research and associated outputs, and methods necessary to implement the Strategy is not even on track yet in Morocco.

Plant Diversity Is Urgently and Effectively Conserved

As an embodiment of the Strategy's overall and ultimate goal, it is not surprising that the second objective comprises almost half the 16 targets (targets 4, 5, 6, 7, 8, 9 and 10). In Morocco, although the progress achieved varies across targets, none of them displays sufficient attainment rate to meet 2020.

Between the 15% of each ecological or vegetation type effectively managed and/or restored as stated in the GSPC target 4 and the proportions of protected areas (17%) of terrestrial ecosystems targeted through the CBD-Aichi targets, Morocco is struggling with managing existing protected areas. The use of protected area approach is actually privileged in Morocco as a primary measure for ecosystem conservation. However, without appropriate management plans, law enforcement, adequate governance, control of threats, etc., it is difficult to attain the conservation desired. Conservation needs differ from one protected area to another. Some situations may require restoration, introduction, or reintroduction of plant species.

GSPC Target 5 states that at least 75% of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity. In the global progress report, Sharrock et al. (2014) notes that 'at the national level, while a number of countries have made significant efforts to identify important areas for plant diversity, it is not clear how many of these are being effectively managed or how well these are distributed across ecological regions'.

Indeed, Morocco is one of these countries where 19 IPAs are recognized but their effective conservation remains to be seen. As noted before, within the framework of south and east Mediterranean region, 19 IPAs rich in endemics, rare and threatened plants based on existing numbers have been identified (Tables 12, 13, 14 above). The urgent questions now are: how are these IPAs protected, how are they managed, and what scientific research is conducted to assess the status of IPAs' contained species and update existing knowledge. Through its projects and activities in two rural communities of the High Atlas, the Global Diversity Foundation provide some answers, but what about the other important plant areas in other parts of Morocco?

GSPC Target 6 states that at least 75% of production lands in each sector managed sustainably, consistent with the conservation of plant diversity and Aichi target 7 on sustainable agriculture, forestry and aquaculture. In Morocco, laws relevant to sustainable land based sectors

have been enacted to ensure protection of the environment from deforestation, coastal erosion, and marine pollution, waste disposal, among others. Earlier sections in this chapter presented examples of protection legislation including the Law n°. 11-03 of May 12, 2003 on "the protection and improvement of the environment," and Law n°. 12-03 of May 12, 2003 retated to "environmental impact assessment." However, law enforcement remains the weakest link in the implementation chain. In addition, despite all efforts and achieved progress, production methods and crop choices in agriculture are not all sustainable in the long-term such as the production of watermelon in the Zagora region located in a desert climate with water being rather scarce and Zagora city dwellers acknowledge purchasing water for their consumption needs because of the city frequent water interruptions. Other issues constraining target 6 achievement by 2020 include the lack of coordination across sectors and the ignorance or at best sporadic incorporation of plant conservations specifics in adopted approaches and management practices.

Both Target 7 and Target 8 are concerned with threatened plant species with at least 75% of known threatened plant species conserved in situ and at least 75% of threatened plant species in ex situ collections, preferably in the Country of origin, and at least 20% available for recovery and restoration programs. These two targets are in perfect harmony with the CBD Aichi Target 12 aiming at the prevention of extinction and the improvement of the conservation status of threatened plants, particularly those known to be declining.

Heywood & Dulloo (2005) expressed their skepticism about the practical feasibility of Target 7 as stated in the first Global Plant Conservation Strategy. As stated, "the target of 60% of the world's threatened species conserved *in situ* by 2010 proposed in the Global Plant Conservation Strategy will not be practicable in a formal sense (management, action or recovery programmes) except for a minority of these. For the majority of threatened species (which have been recently estimated as numbering roughly 80,000–100,000), other kinds of action, such as strengthening the role of protected areas in which they occur, surveying and monitoring of populations, moderating or removing the

source of the threats, may afford some degree of protection" (Heywood & Dulloo, 2005).

Table 19. Summary of progress towards the global strategy of plant conservation targets in Morocco (based on the review of progress in Morocco by the Global Diversity Foundation (GDF) and available literature on the subject)

Target	Reported progress	Relation to CBD-2020-Aichi Targets
T-1: Online flora of all known plants	The GDF has contributed to working lists of regional biodiversity hotspots, a national list of endemic species and a checklist of medicinal species through bibliographic research and by producing local herbarium specimens (online database accessible at http://herbaria.plants.ox.ac.uk/bol/Morocco**)** **.**	T-19: Knowledge improved, shared and applied
T-2: Assess conservation status of all known plant species	A small portion of the Moroccan flora has been assessed resulting in the first Red list of 60 endemic monocotyledons species and 11 medicinal plants) (GDF); Rankou et al. 2015.	T-19: Knowledge improved, shared and applied
T-3: Develop & share information, research and methods necessary to implement the strategy	Development of an integrated agroecology-biodiversity approach to plant conservation. Development of collaborative methods for implementing the integrated approach (GDF).	T-19: Knowledge improved, shared and applied
T-4: 15% of world ecological regions secured	Improvement of the species richness, enhancement of habitat connectivity, and conservation of threatened species through *ex situ* measures in the Important Plant Areas of the Moroccan High Atlas (GDF).	T-11: 17% of terrestrial and inland water, and 10% of coastal and marine areas conserved as protected areas
T-5: 75% of important plant diversity areas protected	19 Important Plant Areas identified in Morocco as part of priority sites of Important Plant Areas of the south and east Mediterranean region (Radford et al. 2011). *In situ* biodiversity conservation with an overview of Morocco's mountain forest ecosystems and flora diversity (Taleb, 2016).	T-11: 17% of terrestrial and inland water, and 10% of coastal and marine areas conserved as protected areas

Target	Reported progress	Relation to CBD-2020-Aichi Targets
T-6: 75% of production lands in each sector managed sustainably, consistent with the conservation of plant diversity	National agriculture is increasingly integrating more sustainable production methods (e.g., no- till, water saving irrigation techniques). The forestry sector is also adopting more sustainable management practices. In recent years, there has been an increase in certification and labelling initiatives for argan products, wild medicinal plants, and other plant products.	T-7: Sustainable agriculture, aquaculture and forestry
T-7: 75% of known threatened plant species conserved *in situ*	Conservation of threatened taxa *in situ* via a range of methods and practices (GDF). Given the significant number of threatened plant species in Morocco and prevailing knowledge gaps, *in situ* conservation of these plants is a serious challenge.	T-12: Extinction of known threatened species prevented and their conservation status, particularly of those most in decline, improved and sustained
T-8: 75% of threatened plant species *in ex situ*, and 20% available for recovery programmes	With the exception of the botanic garden of the Institut Scientifique, the remaining botanic gardens have limited capabilities for conserving threatened plant species. *Ex situ* conservation of threatened plants and recovery plans for such a high proportion of species constitute a challenge.	T-12: Extinction of known threatened species prevented and their conservation status, particularly of those most in decline, improved and sustained
T-9: 70% of crop genetic diversity including their wild relatives conserved	The Settat gene bank achieved a great progress since its creation in 2002. Since most accessions are crop-related, wild plants and cop wild relatives are under-represented. Local knowledge is not receiving due attention.	T-13: Genetic diversity maintained
T-10: Effective management plans to prevent and mitigate threats of invasive species	There are important plant areas in Morocco but the information is lacking on management plans and how they are handling invasive species. Some invasive plants are becoming very noxious.	T-9: Invasive alien species prevented and controlled
T-11: No species of wild flora endangered by international trade	Only 9 taxa are included in the list of plant species as a response to CITES in national legislation.	T-4: Sustainable production and consumption
T-12: All wild harvested plant-based products sourced sustainably	In the context of implementation of the National Strategy for the sustainable management and development of medicinal and aromatic plants in Morocco, the United Nations Development Programme launched a three-year project (2012 - 2015) using	T-4: Sustainable production and consumption

Target	Reported progress	Relation to CBD-2020-Aichi Targets
	FairWild Standard principles. The project aimed at strengthening the capacity of government institutions, non-governmental organizations and concerned private sector actors. Target species include *Rosmarinus officinalis*, *Thymus saturejoides*, *Anacyclus pyrethru*m, *Origanum elongatum*, *Origanum compactum*.	
T-13: Maintain and increase indigenous knowledge, innovations and practices	Assessment of the status of medicinal roots species to identify the possible economic value of plant-based livelihoods to local people and economies. Recording of local names and uses of plants in Imegdale community (GDF).	T-18: Traditional knowledge respected and fully integrated and reflected in the implementation of the Convention
T-14: Promote the importance of plant diversity and integrate the need for its conservation into education and public awareness programmes	Training of community members, students, and local researchers in developing botanic knowledge, collecting voucher specimens and building identification skills (GDF).	T-1: Awareness increased
T-15: Train sufficient plant conservation specialists and provide appropriate facilities to attain national targets of the Strategy	Fennane's statement on the discrepancies between national needs in research and training opportunities and the existing staff and facilities is telling (Fennane, 2008). Another statement by Fennane & Ibn Tattou (2012 "The scientific and environmental challenges are very great. Let this observation clarify the voice to scientists and decision-makers working for the present and future good of our green capital.	T-19: Knowledge improved, shared and applied
T-16: Establish and strengthen plant conservation networks at all levels	Two networks focusing on plant conservation in Morocco: a) the IUCN specialist group Moroccan Plant and Livelihoods Specialist group and b) the Moroccan Biodiversity and Livelihoods Association (Global Diversity Foundation).	T-19:Knowledge improved, shared and applied

As globally addressed by Leadley et al. (2014) based on existing literature, "plant species are mainly affected by loss, degradation and increased fragmentation of habitats, and alien invasive species. In the future, the threat from climate change is predicted to grow. Genetic erosion

and extinction have been identified as important threats to the crop wild relatives and to plant populations that occur on islands. Aquatic plants are affected by ecosystem modification and loss caused by the transformation of wetland habitats, and the intensification of agricultural activities accompanied by eutrophication and pollution. In some countries, the collection of wild plant species (for medicines, food, aesthetic value, or value for collectors) is causing a loss of species and a reduction in reproductive success."

In Morocco, achieving targets 7 and 8 or even getting closer is rather unlikely given the significant number of threatened plants species, the existing knowledge gaps in their conservation status, the nature and degree of threats, the decrease in resource allocations to plant science and related research, the capacities and scope of the Country's botanic gardens, and the climate change entering strongly in the equation.

Conservation implies the eradication or at least the control of threats behind the degradation and eventual loss of the species. National endemic plants are among the rarest and most threatened plants. Their availability in the future based on protected areas is at risk if no particular measures are taken to ensure their continued presence *in situ* and *ex situ.* The challenge of plant conservation in Morocco lies in the significant numbers of rare and/or threatened plants within the national flora, the share of endemics in this group, and the lack of updated information and conservation assessment. Based on Fennane and Ibn Tattou (1998), the number of rare taxa in Morocco amounts to 2193 (Table 5). Most importantly is the significant share (59%) of the very rare group while suspected rare and very rare taxa contribute about 20%. The situation is exacerbated with the serious knowledge gaps and the lack of updated assessments regarding their status. Box 8 illustrates the case of a priority 1 level SIBE studied recently showing the significance of rare taxa and the lack of past baseline referential situation to use for comparison purposes.

Box 8: Kharrouba SIBE - A priority 1 level SIBE with 72% of taxa considered rare to very rare

Located in the Central Plateau of Morocco, Kharrouba SIBE covers an area of 6,300 hectares characterized by mountainous topography. Based on the factsheet, the SIBE aims at protecting Tetraclinis articulata as the primary forest formation.

In the absence of a previous floristic inventory, a recent assessment of the plant diversity of the SIBE listed 143 taxa belonging to 54 families and 123 genera (Dallahi et al., 2016a). Most importantly, the study emphasized the fact that 72% of inventoried taxa are rare to very rare and on the brink of extinction. The causes mentioned by the study include illegal woodcutting and overgrazing (Dallahi et al., 2016a). Another recent article reports that out of 145 plants present in Kharrouba SIBE, 52 are medicinal plants of which 7 are abundant, 13 moderately abundant, and 32 are rare to very rare (Dallahi et al., 2016b).

Almost half of Morocco's flora falls in the threatened group. This translates in the tremendous efforts required to address their *in situ* and *ex situ* conservation within the three years left to 2020. Unless extraordinary initiatives are designed specifically to tackle issues related to threatened plants species, achieved results will always remain limited. As observed by Heywood (2014) citing the fourth National Report to the CBD, there is no national objective that corresponds to Target 7 of the GSPC. However, protection of certain threatened plant species has always been one of the objectives of the national biodiversity strategy and action plan and protected area system in Morocco.

GSPC Target 9 states that 70% of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species are conserved while respecting, preserving and maintaining associated indigenous and local knowledge. In parallel, the Aichi target 13 on maintaining and safeguarding genetic diversity and minimizing genetic erosion extends the plant groups to cultivated plants, wild crop relatives, and other socioeconomically as well as culturally valuable species. Morocco has made great progress in seed banking from both quantitative

and qualitative (Saidi et al., 2007; Ouabbou et al., 2016). However, given the importance of national plant diversity, the challenge remains with respect to collecting seeds of all crop wild relatives, minor crops, medicinal plants, ornamental plants, etc. The diversity of uses and values of existing plants must be included in the national plant conservation agenda. As rightfully highlighted by Sharrock et al., (2014), it is likely to meet the target of maintaining genetic diversity of globally important major crops and the challenge is to maintain genetic diversity for the many thousands of other species that are of socioeconomic importance nationally and locally.

GSPC Target 10 states that effective management plans are in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded. Globally, the rationale behind this target is the control of invasive plants and the prevention of new invasive plants from invading important plant areas using appropriate management plans. The Article 8 (h) of the CBD states "Each contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species." In addition, the Aichi Target 9 states that invasive alien species must be subjected to a prioritization process for better prevention and control by 2020. In Morocco, the 09-05 Law related to CITES helps controlling invasive plants at the frontiers. From a scientific perspective, Taleb & Bouhache (2005) argue that the Country does not have any official list of plants said to be invasive or noxious. Table 20 presents the list of 18 plant species introduced into Morocco based on specialists' field observations and investigations since 1980 (Tanji & Taleb, 1997, Taleb & Bouhache, 2005).

During the 20th century, thirteen weed plants have been introduced in Morocco and have become invasive because they have easily adapted to arid Mediterranean climate and soil types (Tanji & Taleb, 2010). *Solanum cornutum* and *Panicum capillare* have disappeared from the sites where they were first collected with Solanum cornutum reappearing as an invasive plant in another site (Tanji, unpublished data). Several species have become major weeds of irrigated crops in more than one region of the

Country (Tanji, unpublished data). *Ricinus communis* and *Nicotiana glauca* are increasingly invading disturbed habitats everywhere in Morocco. *Verbesina encelioides* is also stretching its presence in stronger ways throughout the Country. Recently, Tanji & Fennane have identified *Dinebra retroflexa* (*Poaceae*) as a newly introduced plant in the Beni Mellal region (forthcoming).

Table 20. Introduced weed plants (invasive) using updated nomenclature (family and scientific name), Moroccan names

Family	Scientific name	Year of introduction	References	Moroccan names
Amaranthaceae	*Bassia scoparia* (L.) Scrad.	1948	(1), (2)	شطابا
Asteraceae	*Ambrosia coronopifolia* Torr. & A. Gray	1990	(3)	-
Asteraceae	*Verbesina encelioides* (Cav.) Benth. et Hook.	1997	(1), (2)	-
Cyperaceae	*Cyperus difformis* L.	1980	(1), (2)	ديس رطب
Euphorbiaceae	*Ricinus communis* L.	Before 1931	(1), (2)	وريورا
Euphorbiaceae	*Euphorbia heterophylla* L.	1980	(1), (2)	-
Lythraceae	*Ammania coccinea* Griseb.	1980	(1), (2)	-
Malvaceae	*Abutilon theophrastii* Medik.	1980	(1), (2)	ابوتيل
Malvaceae	*Corchorus olitorius* L.	1990	(1), (2)	ملوخيا
Oxalidaceae	*Oxalis pes-caprae* L.	Before 1931	(1), (2)	حميضا
Poaceae	*Echinochloa phyllopogon* (Stapf) Koss	1980	(1), (2)	-
Poaceae	*Dactyloctenium aegyptium* (L.) Richt.	1980	(1), (2)	-
Poaceae	*Brachiaria eruciformis* (Smith) Griseb.	1970	(1), (2)	نجيجيما
Poaceae	*Panicum capillare* L.	1990	(1), (2)	-
Solanaceae	*Nicotiana glauca* L.	Before 1931	(1), (2)	هبيلا، مصاصا
Solanaceae	*Salpichroa origanifolia* (Lam.) Baillon	1949	(1), (2)	لوايا
Solanaceae	*Solanum elaeagnifolium* Cav	1949	(1), (2)	شوكا
Solanaceae	*Solanum cornutum* Lam.	1986	(1), (2)	-

Sources: (1) = Tanji & Taleb (1997). (2) = Taleb & Bouhache (2005). (3) = Tanji & Taleb (2010).

Plant Diversity Is Used in a Sustainable and Equitable Manner

This third objective of the GSPC on the sustainable and equitable use of plant diversity presents a double challenge, the sustainability challenge and the equity challenge, each with own constrains and difficulties. The objective comprises GSPC targets 11, 12, 13. While both targets 11 and 12 fit the Aichi target 4 on sustainable production and consumption, the GSPC target 13 relates to Aichi Target 18 on traditional knowledge and the necessity of its respect and integration throughout the implementation of CBD.

GSPC Target 11 is categorical that international trade endangers no species of wild flora. The Convention (CITES) exists since the early 1970's and it is continually being revised to contribute to the achievement of the CBD strategic plan and Aichi targets, particularly the sustainable use of biodiversity. CITES stipulates that no species of wild fauna or flora become or remains subject to unsustainable exploitation through international trade, thereby contributing to the significant reduction of the rate of biodiversity loss and making a significant contribution towards achieving relevant Aichi targets.

Morocco ratified CITES in 1976 and published the text and appendices of the Convention in 1980, issued the national law pertaining to CITES in 2011, and the decree for the law to enter into force in June 2015 (Bulletin Officiel n° 6366). The list of plant species formally covered by the decree includes nine species only (Table 8). This number is very low compared to the number of rare and threatened plant species in need for protection, compared to the list of about 700 plant species protected under the Bern Convention and to over 25,000 plant species included in the Appendices of CITES.

The entire family of *Orchidaceae* (with an estimated 18,000-30,000 species) is included in Appendix II of CITES (Sharrock et al., 2014. Unlike many other countries where wild orchids seem to be well-known plants with popular uses, Morocco's wild orchids are hardly used by local communities. In many countries of the Middle East, tuberous roots of wild orchids are powdered for the preparation of nutritious drink called 'sahlep'. This use is not known in Morocco. With the exception of some local

harvesting of wild orchids for sales of tubers, even local medicinal uses of wild orchids in Morocco is underreported. Dobignard & Chatelain (2010) notes that Morocco's *Orchidaceae* counts 46 taxa belonging to 13 genera, and 2 endemic species. Fennane & Ibn Tattou (1998) reported that *Orchidaceae* family in Morocco contains 11 rare and threatened taxa of which 9 considered very rare (RR) and 2 suspected rare (R?). With the continuous, often uncontrolled disturbance of the plants fragile habitats, *Orchidaceae* is certainly affected.

GSPC Target 12 states that all wild harvested plant-based products are sourced sustainably. According to Sharrock et al., (2014), 'Sourced sustainably' ensures that practices along the supply chain integrates social, environmental, and economic considerations such as the fair and equitable sharing of benefits and the participation of indigenous and local communities. There is need to inventory plant-based products (and identify the species from which they are derived), and to assess or certify their sustainability according to explicit and scientific criteria (Sharrock et al., 2014). In Morocco, wild harvested plant-based products are not adequately defined. Nor are the species at the origin of plant-based products identified. One example to illustrate this case is *Muscari comosum* (*Hyacinthaceae*). For decades, the bulb of this plant is wild harvest throughout Morocco for the export market. Box 9 addresses some of the crosscutting issues as they relate to *Muscari comosum* based on field observations and existing literature.

Box 9: *Muscari comosum* exported for decades as 'wild onions'

Muscari comosum (*Hyacinthaceae*) is a common species in Morocco. The plant grows in cultivated fields, fallow parcels as a weed. Nègre (1961) described the plant under the local names of 'bousla' and 'âansl sghir' as a plant without any pastoral value but carefully collected by inhabitants. In the Oriental region, the popular name of *Muscari comosum* is 'kikote' (Kahouadji, 1995) and in Marmoucha, the plant is called 'bsel n-iqzine' (Nassif & Tanji, 2013b). Although local names vary across regions, the most frequently used name is 'basseila' which is a diminutive variant of the Moroccan name for onions 'basla'. Boulet et al., (1989) attribute a value of 2 to the plant based

using a 1 to 5 index of agronomic harmfulness with 5 being most noxious. Tanji (2000) cites *Muscari comosum* as one of the ten most important perennial weeds in barley and wheat fields in the Tadla region. *Muscari comosum* is not grazed by animals but the bulbs are collected to be exported to be used as food and in pharmaceutical industry (Tanji, 2005).

Muscari comosum is wild-harvested for sales in local rural markets. Collectors from these markets are intermediaries for larger commercial establishments specialized in trade and exports. Immediately after the appearance of the first leaves, children and adults as well start scavenging fields for the collection of bulbs. Total collected quantities are sorted out and exported in sacs since no local human consumption is reported in Morocco. Most people who annually collect bulbs do not know their uses once exported. Moreover, ethnobotanical studies in Morocco hardly mention the use of the plant in local traditional phytotherapy. Only few studies have reported the use of the plant in traditional medicine. The use of the decoction of bulbs as diuretic in the Oriental region is reported in Kahouadji (1995). Rhafouri et al. (2015) report the local use of bulbs as an antidiabetic and against rheumatism in the form of infusion and cataplasm by people in the National Park of Ifrane. *Muscari comosum* is listed among medicinal plants inventoried in the Khénifra province without any information on use (Zerkani et al., 2015).

The wild-harvest of bulbs of *Muscari comosum* for export is an old widespread commercial activity in Morocco. Annually, tonnes of bulbs of the plant are exported, particularly to Europe. According to Gattefossé (1941), since ten years, *Muscari comosum* is harvested for export to the United States of America. As also reported by Gattefossé (1941), the bulb of the plant represents traditional food for the Greeks and the Italians of the South specially during the fasting that precedes Easter. This tradition goes to the ancient antiquity and the Greeks and Italians migrating in the new world insist on having this appreciated and almost ritual food. Gattefossé (1941) pointed out that the export of the bulbs of *Muscari*, registered in customs under the name wild onions, generates a turnover of several million francs a year. Nonetheless, the export has decreased because the USA required total disinsectization of bulbs at departure and also because the rapid rarefication of *Muscari* in accessible collecting areas.

Until today, *Muscari comosum* continues to be registered and exported as wild onions, often included under transformed agricultural products with wine, spices and herbs, olive oil, and dates.

Based on some data of the year 2003, Morocco's exported quantities of wild onions amounted to 2.360 tonnes (http://www.amb_Maroc.fr/Economie_marocaine/eco_secte_industr_agro_alimentaire.htm).

According to one informant with a shop for purchasing locally collected plant species in Imouzzer Marmoucha (Boulemane province), collected quantities and prices of bulbs of *Muscari comosum* vary annually and seasonally with the period of activity stretching from early February to mid-april. In general, highest prices are offered at the beginning of the season and lowest prices at the end of the season. This informant estimated that the annual average quantities transited through his shop amount to 10 tonnes. (Nassif, unpublished data). Khabbach et al. (2012) reported that in Taza province, collecting wild *Muscari comosum* provides a source of income and about 17.5 working days per year for local population, particularly women and children. The average price for the 2012 year was 10 dh/kg and the quantities collected estimated at 83.5 tonnes for the same year (Khabbach et al., 2012).

One of the consequences of annual harvesting of bulbs, exacerbated by episodic droughts, is the decrease in the plant availability. In Oued Zem region (Khouribga province), this activity is heavily practiced because of availability and the establishment of a nationally recognized market for export. In a recent field visit to Oued Zem (March 3, 2017), many local informants recognize that harvesting *Muscari comosum* is becoming more and more difficult because of increasingly reduced availability. Two additional visits were conducted to Oued Zem (March 29, 2017) and Berrechid (April 5, 2017) to the collecting units of one of the two national exporters of *Muscari comosum*. From the discussions with the persons in charge of these units, it was learned that:

- collected quantities for the year 2016-2017 is situated between 250 and 300 tonnes;
- the collecting season usually stretches between mid-december and end of March;
- volumes of collected bulbs vary annually;
- in recent years, there has been a significant decrease in collected volume, with the turning point starting at the beginning of the third millennium;
- before the year 2000, collected volumes were situated around 3,000 tonnes;
- in general, two thirds of collected quantities is exported fresh after

cleaning and sorting while the remaining third is pickled, then exported;

- Italy is the major importer of Morocco's wild onions;
- there is a difference in qualities of collected bulbs, with Chaouia region supplying the best quality bulbs;
- prices vary annually and within the collecting season;
- fresh wild onions are exported in 25 kg onion-bags; and
- pickled onions are exported in 200 Liter barrels.

Two unfortunate features are associated with wild harvested *Muscari comosum* for export. First, statistical data on the importance of export volume and value and the beneficiaries of *Muscari comosum* market chain are unavailable. Second, research on seed-propagation of the plant and /or alternatives to wild-exploitation is lacking. A recent published study on seed-propagated *Muscari comosum* in Southern Italy concludes that mass propagation could be performed for agronomic purposes using nurseries (Candido et al., 2016). The study also concludes that due to the high rate of germination and the ease of obtaining the seeds from wild populations or from cultivation, there is the possibility to produce large quantities of bulbs to develop new crops of this traditional food.

Source: Nassif and Tanji, unpublished data.

GSPC Target 13 states that indigenous and local knowledge, innovations and practices associated with plant resources are maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care. The sustainable and equitable use of plant diversity implies the preservation and the enhancement of local knowledge. The use of plants evolves based on communities and people's genuine ability to relate to their environment and its resources.

In Morocco, with the exception of the use of plants in traditional health care, the other many uses of plants such as witchcraft, perfumery, condiments, veterinary medicine, have not received much attention. Until today, the work of Bellakhdar (1997) stands as the most comprehensive, the most rigorous and well-researched reference on Morocco's traditional

pharmacopoeia. Over the years, Morocco's ethnobotanical research supplies a wide range of articles. Contributions of the authors in this sense consist of an article on edible weeds (Tanji and Nassif, 1995), wild gathered food plants (Nassif and Tanji, 2013a) and the role of plants in saving lives during famine times (Nassif and Tanji, 2013c). In Morocco, local knowledge, innovations and practices associated with plants are rich and diverse and deserve research and documentation in their own right. The cultural diversity of Moroccan society is as rich as its biological diversity.

Promoting Education and Awareness About Plant Diversity, Its Role in Sustainable Livelihoods and Importance to All Life on Earth

Operationalized in GSPC Target 14, this objective puts emphasis on the importance of plant diversity and the urgency of integrating the need for its conservation into communication, education and public awareness programs. This goes in line with Aichi Target 1 stating that by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve it and use it sustainably. In Morocco, the Global Diversity Foundation has done some work in two communities in the High Atlas.

Developing the Capacities and Public Engagement Necessary to Implement the Global Strategy for Plant Conservation

This objective covers targets 15 and 16 of the GSPC, both related to Aichi Target 19 on improvement, application and sharing of knowledge.

GSPC Target 15 states that the number of trained people working with appropriate facilities is sufficient according to national needs, to achieve the targets of this Strategy. Needless to repeat that the situation in Morocco is reaching alarming stages. Fennane's message on discrepancies between the national needs in research and training opportunities and the existing staff and facilities is telling (Fennane, 2008). The decline in the number of researchers and scientists because of the voluntary departure policy and retirement without hiring and or training new ones is challenging.

GSPC Target 16 states that institutions, networks and partnerships for plant conservation are established or strengthened at national, regional and international levels to achieve the targets of this Strategy. In Morocco, the Global Diversity Foundation has established two networks.

Visibly, overall progress, in Morocco, is rather slow and the constraints are tremendous with crosscutting issues in almost all areas. These include the lack of coordinated effort to create synergies between *in situ* and *ex situ* activities, limited interest in local knowledge, limited role for scientific research in the educational system, non-transparent governance, and weak law enforcement. Major plant groups in need of urgent appropriate interventions in the Country include the already known national endemics comprising 920 taxa (640 species and 280 subspecies) and 14 national endemic genera of the vascular flora (Fennane & Ibn Tattou, 2012). Throughout much of the literature on Morocco's plant diversity, national endemics are used as a trademark of the originality of Moroccan flora. Moreover, a number of species are of restricted range and exist only in Morocco. Thus, the need to conduct rigorous assessments to update their status, their distribution, ascertain the threats affecting their sustainability, their use, their vernaculars, and the local knowledge associated with them. The neglect or even the delay in tackling national endemics can be detrimental not only to Morocco but to the world. Threatened plants of Morocco are another plant group in need of concerted efforts of research, assessment and conservation actions. Field investigations are needed to assess where these plants are, how they are surviving natural and human threats and determine what needs to done. Invasive plants are becoming sources of global concern and they must receive greater attention in Morocco. They are invading larger areas, damaging habitats and threatening native plants. The observation of *Solanum elaeagnifolium* in irrigated areas in Doukkala and Tadla is only an example of how invasive and how noxious this plant species is.

Globally, two of the seven key messages stated in the CBD 2009 plant conservation report cannot be emphasized enough. The first message indicates the numerical importance of threatened plants worldwide. The report states that "two thirds of the world's plant species are in danger of

extinction with pressure from the growing human population, habitat modification and deforestation, over-exploitation, spread of invasive alien species, pollution and the growing impacts of climate change" (CBD, 2009). The second message refers to the limited progress achieved at the global level. The report states that, "while substantial progress has been reported for eight of the sixteen targets, limited progress has been made so far in the achievement of others, notably on Target 2 (completion of preliminary conservation assessments), Target 4 (ecological regions conserved), Target 6 (conservation of biodiversity in production lands), Target 12 (sustainable use of plant-based products) and Target 15 (capacity and training for plant conservation)" (CBD, 2009).

The mid-term review of progress towards the 16 targets of the revised GSPC was conducted in early 2014 (Sharrock et al, 2014). The review reveals that progress is achieved towards all targets, but generally not at sufficient rate to achieve the targets in full by 2020. Lack of information on the distribution and conservation status of plants constrains efforts to conserve plants effectively, both *in situ* and *ex situ*. Furthermore, as the threats to plant conservation increase, botanic capacity and funding for plant conservation are decreasing in many parts of the world (Sharrock et al., 2014). The report recommends that CBD parties further engage with partner organizations to make the best use of available expertise and find ways to involve indigenous and local communities to enhance plant conservation (Sharrock et al., 2014). While there is evidence of positive progress on a number of targets, the overall picture is poor, with inadequate progress to date in most countries, and weak levels of future ambition. Based on the current trajectory, the world will not meet all the 16 GSPC targets, nor will it meet the 20 Aichi targets (Sharrock et al., 2014).

In practice, countries are addressing their national plant conservation issues in so many different ways. In fact, as suggested by Havens et al. (2014), "there is no one formula for effective nationwide plant conservation, but there are elementary needs that need to be addressed." Havens et al. (2014) enumerate the following elements a) accessible up-to-date information on species distribution and rarity, b) the ability to mitigate

threats, c), education and training, d) funding and e) effective communications.

CONCLUSION

Conservation of plant diversity in situ and/or ex situ, is a multi-faceted complex process where science, policy, legislation, livelihoods, traditions, and many more natural and cultural elements meet. With about 7,600 inventoried species, Morocco is recognized as one of the richest countries of the Mediterranean region offering eventual potentialities for the future not only in Morocco but worldwide. However, this plant diversity is faced with serious challenges in need to be transformed into strengths and opportunities.

Until today, not all the components of Moroccan flora are adequately known and assessed. Significant numbers of threatened, rare and endemic plants are poorly known. Filling the knowledge gaps through constant research and assessments is essential for setting priorities, developing appropriate measures, and implementing effective conservation plans. Information is key to plant conservation. In fact, prevailing knowledge gaps are recognized by the specialists themselves as one of the challenges of Moroccan flora. With exception of about 60 plant species effectively assessed and red listed based on IUCN criteria and categories, the rest of the flora is awaiting and there is no national red list for all threatened plants of Morocco. Fennane & de Montmollin (2015) reported that the global IUCN Red List currently includes 422 species considered to be present in Morocco; 43 are national endemics. The authors draw attention to the importance of updated assessments and the difficulties associated with information needs of Red Listing based on the IUCN methodology. More precisely, Fennane & de Montmollin (2015) wrote “among the 422 species of this list, 25 are absent from Morocco or of doubtful presence. This list covers about 10% of the national vascular flora and less than 7% of its endemics. This shows how important is the work that still remains to

be done in Morocco to increase the species assessments and revise those that are old."

Morocco's genetic resources and crop wild relatives, particularly local knowledge associated with these resources, also suffer from knowledge shortages. Research and filling knowledge gaps are a prerequisite for plant conservation. Effective conservation of plant diversity depends essentially on how are research issues and information needs at the species level (locality, distribution, status, use, threats, etc.) addressed and satisfied. With increased deterioration of habitats and significant effects of multiple threats, the need for plant conservation research has never been greater. Some of the urgent research priorities include conservation & recovery of threatened and endemic plants, invasive species management, use of native plants in ecological restoration, and impacts of climate change on plants and ecosystems.

Mitigating threats is another prerequisite for preserving national plant diversity. Legal protection alone is not sufficient for reaching desired goals. Laws and decrees are necessary instruments but unless accompanied with law enforcement measures and appropriate grounded management plans, they remain ineffective. One of the complex issues in Morocco is the huge discrepancy between legislation and its effective application.

In Morocco, plant conservation engages a wide array of stakeholders and agencies including various state departments, academic institutions, non-government organizations, national, regional and local authorities, etc. Ideally, all these stakeholders are concerned with conserving and valuing national plant diversity. In practice, these stakeholders have different agendas and responsibilities resulting at times in conflicts and/or incompatibilities. Moreover, institutions mandated with plant conservation vary in time and conjuncture. Therefore, coordination of interventions and synergies are fundamental for ensuring effectiveness and efficiency in allocated resources and interventions. Since the Global Strategy for Plant Conservation provides the international framework for actions at national levels. There is need to develop a national framework for implementation and ownership of the Global Strategy through establishing national priorities.

From this perspective, one of the first tasks to be tackled is the definition of domains and the demarcation between biodiversity and plant diversity. Often, concepts of biodiversity, nature, environment, ecosystems, animals, plants and many other terms are used interchangeably not only by common people but also in formal reports, strategies and action plans. The world of plants has its own specificities and plant conservation requires particular approaches and actions. In Morocco, most existing strategies, programs and plans are about biodiversity. Therefore, they are not necessarily responding to plants' needs in terms of information, knowledge, understanding and management. In a word, there is a need to making plant diversity conservation a national priority in order to address the complexity and multifacetedness of this process and bring about its full benefits for the future nationally and internationally.

Knowing, understanding and conserving Morocco's plant diversity is not a mission for botanists exclusively. Plant conservation is an integrative operation where traditional knowledge, climate change, legislation, biological science, volunteering, can contribute. The overall approach must be multidisciplinary. There are inspiring examples from several countries on citizen science and the role of volunteers in monitoring.

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Chapter 2

IMPLEMENTATION OF TOTAL FLUORESCENCE FINGERPRINTING AS A RAPID AND LOW COST APPROACH FOR MONITORING PESTICIDE REMAINS IN SOILS AND WATERS IN MOROCCO

Hicham Hassoun[1], Taibi Lamhasni[1], Salim Foudeil[1], Saadia Ait Lyazidi[1,*], Mustapha Haddad[1], M'barek Choukrad[2], Ahmed Boughdad[3], Luisa Patrolecco[4], Stefano Polesello[5] and Sara Maria Valsecchi[5]

[1]Département de Physique, Laboratoire de Spectrométrie des Matériaux et Archéomatériaux (LASMAR), Unité de Recherche Associée au CNRST, URAC 11, Faculté des sciences, Université Moulay Ismail, Meknès, Morocco
[2]Département de Chimie, Laboratoire de Chimie Moléculaire et Substances Naturelles, Faculté des Sciences, Université Moulay Ismail, Meknès, Morocco

* Corresponding Author address, Email: aitlyazidisaadia@yahoo.fr.

[3]Département de Zoologie agricole,
Ecole Nationale d'Agriculture Meknès, Meknès, Morocco
[4]Water Research Institute, National Research Council, Rome, Italy
[5]Water Research Institute, National Research Council, Milan, Italy

ABSTRACT

The promotion of the agricultural production constitutes a main challenge for Morocco. This goal often results in an increased use of pesticides and fertilizers compromising soils and waters. Moreover, in addition to large stocks of pesticides, the invasion by locusts from southern countries requiring massive use of insecticides remains a potential threat for Morocco. Consequently, a continuous monitoring of the different environmental compartments (soil, water, and air) is increasingly needed for all the Moroccan territory

Owing to hundreds of soil and water samples to control, it is important to develop simple and inexpensive methods to assess pollution levels by pesticides in agricultural soils and neighboring waters. The sophisticated chromatographic methods, in spite of their high accuracy, are very expensive and hardly accessible; they can be reserved for laboratory accurate analyses and statutory inspections.

The purpose of this research is to palliate to this issue by developing a spectrometric approach for monitoring soils and waters; an approach which is effective, fast, easy to implement and reliable. In this sense, fluorescence spectroscopy presents a high potential owing to its high sensitivity, ease and rapidity. Total excitation-emission (TEEMs) and total synchronous fluorescence (TSFMs) mappings make it possible to detect remains of fluorescent pesticides in soils or waters. The present investigation aims at the creation/extension of a total excitation-emission and total synchronous fluorescence mapping database to fingerprint those fluorescent pesticides in large use in Morocco. These fluorimetric fingerprints must allow the direct identification of any targeted fluorescent pesticide persisting in soil or water.

After a large survey among farmers and agricultural product distributors, to target the best-selling and most used pesticides in different Moroccan regions, one hundred and five (105) pesticides have been fingerprinted. Applicability tests were carried out on the basis of field pre-surveys information and total fluorescence results.

In the present work, the maps and synchronous spectra of a set of 57 commercial pesticides are reported. Moreover, four examples of TEEMs/TSFMs fingerprinting applications to recognize pesticide

remains in soil samples are shown. The agricultural plantations monitored are located in the great agricultural region Doukkala at the western Atlantic side of Morocco. The catalogue has been enriched by a PCA-based statistical study to constitute groups of pesticides with similar spectrometric fingerprints. The emitting similarity inside pesticide groups, despite different active principles, was explained by similarity of formulation products.

The implemented spectrofluorimetric approach is satisfying and seems suitable, at least, as a warning method in case of massive contamination of soils or waters.

Keywords: Morocco, pesticides, fingerprinting, total fluorescence, monitoring, soils and waters

INTRODUCTION

Since years ago, the annual importation of pesticides in Morocco reached 12,000 tons (Maroc 2013), while direct users are poorly perceptive workers. Two recent studies conducted at the northern and at the eastern sides of Morocco demonstrated the chemical contamination of ground waters by organochlorines due to extensive use of pesticides (Ben Aakame et al. 2014; Fekkoul 2013). On another plane, among a set of 2704 biological samples for forensic investigations between 2006 and 2014, the National Institute of Hygiene of Rabat identified 2.46% cases of poisoning by endosulfan (Rochdi et al. 2014). Severe intoxication by pesticides is placed in the fourth position with an incidence exceeding 2.56 per 100,000 people (El Khaddam et al. 2013). It must be underlined, however, that the published statistics don't reflect the reality as not all cases are counted. Moreover, the attack by locusts from saharian countries, that requires massive applying of insecticides, remains a potential threat for Morocco. Attentive to this constraint, Morocco is continuously making efforts to raise awareness and to improve the law relative to the trade and delivery of pesticides (ONSSA 2014).

Owing to the high number of soil and water samples to analyze, chromatographic methods are very expensive and time consuming

procedures. In his sense, fluorescence spectroscopy presents a high potential due its sensitivity, rapidity of use and availability in comparison with chromatographic techniques. The present research aims at the creation/extension of a database of total excitation-emission and total synchronous fluorescence maps to fingerprint those fluorescent pesticides widely used in Morocco. The goal is their direct detection when persisting in soils or waters. On the basis of a large field inquiry focusing on the most used pesticides in different agricultural regions, a total of 48 pesticides have been previously fingerprinted (Foudeil et al. 2015). The present work constitutes an extension of this spectral database to 105 pesticides chosen among those largely used ones through various agricultural regions in Morocco. An analogous TEEM based approach, enriched by PARAFAC, has been adopted by Rubio et al. (2014) for the identification and quantification of carbamate pesticides in dried lime tree flowers.

EXPERIMENTAL

The experimental protocol used in the present work is that published in our previous works (Foudeil et al. 2015; Hassoun et al. 2017). The collected commercial pesticide samples were stored at ambient temperature in dark glass bottles, and solutions were prepared in water; the pH values were found between 7 and 8. To avoid any mutual contamination during experiments, all the material used for a pesticide (vials, pipettes, micropipettes and quartz cells) was thoroughly cleaned and dried. Moreover, all laboratory precautions were observed: use of fume hoods, mask, gloves, protective clothing and eyewear.

A large set of commercial pesticides was collected; only those exhibiting native fluorescence were maintained. The lowest concentrations giving spectra with the minimum of noise were adopted.

On all prepared solutions, UV-Visible absorption spectra were recorded on a JASCO UV/VIS/NIR V-570 spectrometer over the 200-800 nm wavelength range.

Fluorescence spectra were measured on a Shimadzu RF-5301 PC spectrofluorometer, over the wavelength range 250-600 nm while excitations were set in the range 220-400/500 nm with a 5 nm step.

Synchronous fluorescence spectra were collected in the wavelength range 250-600 nm, the offset $\Delta\lambda$ was varied between 15 and 200 nm with a 5 nm increment.

Excitation and emission slit widths were set between 1.5 and 5 nm band pass; for each map, to avoid any false replication of emission peaks, these slits were kept unchanged during all spectra measurements.

Processing of the experimental results was performed using the program Origin-Pro version 8.0 (Northampton, MA). Fluorescence emission spectra and synchronous fluorescence spectra were concatenated to generate respectively Total Excitation–Emission Matrices (TEEMs) and Total Synchronous Fluorescence Matrices (TSFMs).

The statistical analysis of the spectral data was carried out by mean of the Principal Component Analysis (PCA) method via the SPSS Statistics version 20 (IBM Corp., Armonk, NY, USA).

METHODOLOGY

Environmental water or soil samples are multi-component matrices which can't be analyzed by mean of conventional fluorescence spectroscopy; the signals of the analytes of interest may overlap each other decreasing thus the selectivity of the method.

An alternative is the use of total fluorescence analysis which may be enriched by chemo-metric methods. In continuation of our previous work (Foudeil et al. 2015), three fluorimetric approaches were then adopted: Total Excitation-Emission Mapping (TEEMs), Total Synchronous Fluorescence Mapping (TSFMs) and the combination of Synchronous Fluorescence Spectra (SFS), at optimal offsets, with their corresponding First Derivative ones (FDSFS). TEE and TSF maps are fluorescence contours/areas, in which emission scans are collected respectively at manifold excitation wavelengths $\lambda_{exc.}$ and at manifold offsets

$\Delta\lambda$ (= $\lambda_{em.}-\lambda_{exc.}$). The fluorescence intensity maxima features are characterized as ($\lambda_{exc.}$, $\lambda_{em.}$) couples on the TEE matrices, or ($\Delta\lambda$, $\lambda_{em.}$) couples on the TSF ones. Andrade-Eiroa et al. (2013) and Carstea (2012) reported a review on applications of excitation-emission spectrofluorimetry in environmental analyses. All together, TEE and TSF maps with optimal Synchronous Fluorescence Spectra (SFS), combined to their First Derivative ones (FDSFS), can be considered as a multi-component fluorimetric mark with valuable features to identify a particular compound in a mixture and then characterize the soil or water multi-fluorophoric systems. Furthermore, it must be underlined that even if the observed fluorescence signal may originate from formulation products of pesticide mixtures, its existence in a soil or water sample spectrum implies the persistence of chemicals constituting these commercial pesticides. Consequently, any fluorescence signal emitted by each studied pesticide, dissolved in water, was recorded. The excitation and emission slit widths were set between 1.5 and 5 nm band pass. The spectra collected at 5 nm (exc.)/5 nm (em.), 3 nm (exc.)/5 nm (em.), 3 nm (exc.)/3 nm (em.), 1.5 nm (exc.)/3 nm (em.) and 1.5 nm (exc.)/1.5 nm (em.) correspond respectively to pesticides classified as moderately fluorescent, good fluorescent, highly fluorescent, very highly fluorescent and excellent fluorescent; this description is more qualitative than quantitative. On the TEE maps, the first and second orders of the Rayleigh scattering lines were removed by truncating them from the raw emission spectra. The negative values at the sides of the TSF maps originate from the subtraction of water blank synchronous spectra from those of the pesticide solutions; no perturbation is induced by this operation on the whole maps. Manual peak picking permitted to locate fluorescence peaks as two coordinates sharp areas on both TEE and TSF maps. The couples of coordinates are respectively ($\lambda_{exc.}$, $\lambda_{em.}$) on the TEE maps and ($\Delta\lambda$, $\lambda_{em.}$) on the TSF ones. The identification based on the location of peaks on Total Excitation-Emission Maps (TEEMs) has been often adopted to characterize dissolved organic matter in marine and freshwaters (Coble 1996; Coble et al. 1990; Ghervase et al. 2011; Parlanti et al. 2000; Tedetti et al. 2010), to assess drinking water

treatments (Markechová et al. 2013) and to discriminate PAHs and pesticides in complex mixtures (Ferretto et al. 2014).

RESULTS AND DISCUSSIONS

Catalog

In the present investigation, the 57 fingerprinted pesticides showing a native fluorescence have been divided into five groups considering their chemical properties: i) Carbamates and Thiocarbamates, ii) Organophosphates, iii) Triazoles, iv) Pyrethrinoids and Minerals and v) non-assigned pesticides.

Carbamates and Thiocarbamates

Carbamates and Thiocarbamates pesticides are deriving from carbamic acid. They are short living in the environment; while temperature or pH increase their chemical transformation is accelerated (Glaser 1999). Recently Sircu et al. (2015) reported the results of pesticide residues analysis in many fruits and vegetables using chromatographic instrumentation; residues of Carbamates were found. In the present catalog, seventeen Carbamates and Thiocarbamates were fingerprinted; they are the commercial mixtures Betanal Expert 274 EC, Salvador 25 WP, Agrizeb 80 WP, Fantic MWG, Matco, Ridomil Gold MZ 68 WG, Trimanoc Bleu, Uthane 80, Cristo MZ 80, Axlera 5G, Emthane M 45, Mancofil, Manfil, Pelt 44, Pergado MZ, Lannate 25 WP and Thiogri 70. The first eight mixtures, are highly fluorescent, the following seven ones are good fluorescent while the two last ones are moderately fluorescent.

Figure 1_a and Figure 2_a show respectively the spectra and maps of the commercial herbicide Betanal Expert 274 EC and the commercial fungicide Cristo MZ 80.

Table 1 shows their corresponding peak coordinates ($\lambda_{exc.}$, $\lambda_{em.}$) on the TEE maps and ($\Delta\lambda$, $\lambda_{em.}$) on the TSF maps in addition to the positions of

maxima, minima and zero points taken on the first derivative synchronous spectra (FDSFS).

Organophosphates

OPPs are a widely used family of pesticides; they are esters or compounds with a thiophosphoryl (P=S) or phosphoryl (P=O) functional groups (Guo et al. 2011; Tankiewicz et al. 2010). Hundreds of tones of outdated pesticide stocks, in different Near East and African countries (Cha et al. 2014; FAO 1999, 1995), consist of OPPs. Moreover, it must be also underlined that the same Organophosphates are also chemical warfare agents acting as nerve agents used in terrorist attacks (Carullo et al. 2015). Numerous assays have been developed to assess OPPs (Guo et al. 2011; John et al. 2008; Marco et al. 1995; Zhao et al. 2009; Zheng et al. 2011); recently Carullo et al. (2015) tried a real time OPPs detection system using an enzymatic sensor based on fluorescence spectroscopy. In the present catalog, a set of three commercial OPPs are characterized; they are: Cyren 480 EC, Choke and Systogor 40. The first one is a good fluorescent mixture while the two others are moderately fluorescent ones. On Table 2 are given the peak coordinates ($\lambda_{exc.}$, $\lambda_{em.}$) and ($\Delta\lambda$, $\lambda_{em.}$) on TEE and TSF maps, in addition to the positions of maxima, minima and zero points taken on the first derivative synchronous spectra.

Triazoles

Triazoles pesticides refer to compounds with a five membered ring of two carbons and three nitrogen atoms; acting as fungicides, Triazoles are widely used in the world since the 1980s. The European Food Safety Authority committed the great NP/EFSA/APPR/2009/01/ project to the exposure review of Triazole pesticides (RIKILT – Institute of Food Safety 2010). Four Triazoles were investigated here; they are those commercially labeled Boon 10 WP, Sonazole 250 EC, Orsalis 5% SC and Hexa 5 SC. The two first pesticides are highly fluorescent; the third and fourth ones are respectively good and moderately fluorescent. Table 3 reports ($\lambda_{exc.}$, $\lambda_{em.}$) and ($\Delta\lambda$, $\lambda_{em.}$) peak coordinates taken on the corresponding TEE and TSF

matrices, along with wavelength positions of the maxima, minima and zero points on the first derivative synchronous spectra.

Pyrethrinoids and Minerals

Synthesized from petroleum derivatives (Fishel 2014), Pyrethrinoids are two types (I and II) differing in chemical structures and formulated in different commercial forms. As they are quickly deactivated by metabolic processes, Pyrethrinoids are not classified among the highly toxic products. In this work, the fingerprinted set of Pyrethrinoids consists of four commercial products; they are Cyrux, highly fluorescent, Decis ES 25 EC and Pulsar, good fluorescent, and Force 0,5 G which is moderately fluorescent.

Mineral-based pesticides include sulfur and various forms of copper. Sulfur has been used as pesticide since ancient times, while copper based pesticides were discovered in the late of the 1800s. Regarding oral toxicity, these latter are category II (Savage 2015). The set of the studied minerals consists of six commercial mixtures which are the Megasulph and Sulphur 80% WG, highly fluorescent, the Copas, Microlus Super and Super Coloss, good fluorescent, and the Cobox, moderately fluorescent. Table 4 reports the corresponding peak coordinates ($\lambda_{exc.}$, $\lambda_{em.}$) and ($\Delta\lambda$, $\lambda_{em.}$) along with positions of maxima, minima and zero points taken on the first derivative synchronous spectra.

Non-Assigned Pesticides

The investigated group of non-assigned pesticides consists of 23 commercial products of different chemical properties, acting as herbicides, fungicides, insecticides or otherwise. They are classified in three subgroups. The first sub-group contains those called Derby 175 SC, Foltax 50 WP, Golden Mirowet, Goltix 90 WG, Illoxan 36 CE, Lafaloun, Match 050 EC, Mesurol 50 WP and Proclaim 05 SG; all of them are highly fluorescent. The second sub-group contains the commercial products Ghlala, Actara 25 WP, Cyclo Drop, Denim Fit, Equation Pro, Revus MZ 65 WG and Select Super; they are good fluorescent mixtures. The third sub-group shows seven commercial pesticides moderately fluorescent; they

are Lontrel 100 SL, Appariol, Bourgui, Glyweed, Herboxone, Leili 2000 and Menjel 24 EC.

Figure 3_a and Figure 4_a show respectively the spectra and maps of the commercial molluscicide Ghlala and the commercial herbicide Lontrel 100 SL.

Table 5 reports the corresponding peak coordinates ($\lambda_{exc.}$, $\lambda_{em.}$) and ($\Delta\lambda$, $\lambda_{em.}$) along with positions of maxima, minima and zero points taken on the first derivative synchronous spectra.

Applicability Tests of the Spectral Database

Pre-Surveys, Sampling and Samples Preparation

Two soil sampling campaigns were carried at the huge agricultural region of Doukkala in the western side of Morocco. In order to get information relative to previous chemical treatments of cultures and soils, the campaigns were accompanied by large field surveys between local farmers and agricultural laborers at many fields in the sub-regions. Several soil samples were then taken on different agricultural fields in view to monitor remains of pesticides by applying the spectral database results. In this work, we report outcomes obtained on four soil samples taken on different pretreated plantations. A soil sampling was carried out, during a spring period, in a potato plantation field; three other samplings were conducted, during a winter period, in three different sugar beet fields. The potato crop was pre-treated by the commercial Thiocarbamate Cristo MZ 80 (fungicide); the three sugar beet fields were pre-treated by the commercial Carbamate Betanal Expert 274 EC (herbicide), the Cyclo-octane Ghlala (molluscicide) and the Picolinic acid Lontrel 100 SL (herbicide). At the same time, other soil samples were also collected from a neighboring non-treated field.

Table 1. Active compounds along with TEEMs, TSFMs and FDSFS peak coordinates of Carbamates and Thiocarbamates

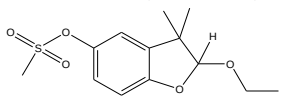
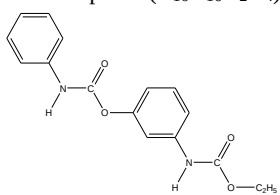
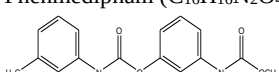
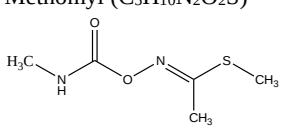
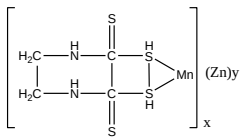
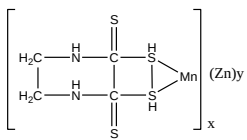
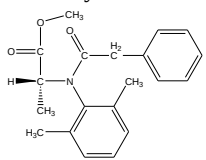
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Highly fluorescent	Betanal Expert 274 EC • Herbicide • E01-6-003	Ethofumesate ($C_{13}H_{18}O_5S$)  Desmedipham ($C_{16}H_{16}N_2O_4$)  Phenmedipham ($C_{16}H_{16}N_2O_4$) 	$\lambda_{exc.}$= 280 nm 305 ≤$\lambda_{em.}$≤ 315 nm	Δλ= 30 nm 305 ≤$\lambda_{em.}$≤ 315 nm	$\lambda_{Max\text{-}point}$= 299 nm $\lambda_{Zero\text{-}point}$= 310 nm $\lambda_{Min\text{-}point}$= 322 nm
	Salvador 25 WP • Insecticide • D05-7-003	Methomyl ($C_5H_{10}N_2O_2S$) 	$\lambda_{exc.}$= 300 nm 355 ≤$\lambda_{em.}$≤ 365 nm	Δλ= 60 nm 355 ≤$\lambda_{em.}$≤ 365 nm	$\lambda_{Max\text{-}point}$= 339 nm $\lambda_{Zero\text{-}point}$= 360 nm $\lambda_{Min\text{-}point}$= 391 nm

Table 1. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Highly fluorescent	Agrizeb 80 WP • Fungicide • E07-4-006	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 295 nm $\lambda_{em.} \approx$ 350 nm	$\Delta\lambda$= 55 nm $\lambda_{em.} \approx$ 350 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 350 nm $\lambda_{Min\text{-}point}$= 363 nm
	Fantic MWG • Fungicide • E12-9-010	Mancozeb($C_4H_6MnN_2S_4)_x(Zn)_y$  Benalaxyl-M 	$\lambda_{exc.}$= 300 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\Delta\lambda$= 55 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\lambda_{Max\text{-}point}$= 341 nm $\lambda_{Zero\text{-}point}$= 354 nm $\lambda_{Min\text{-}point}$= 366 nm

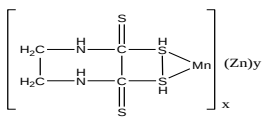
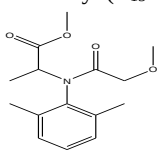
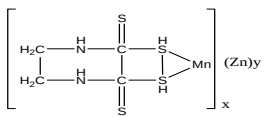
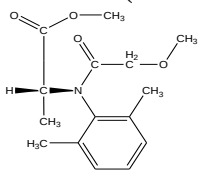
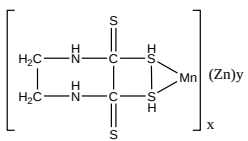
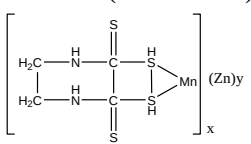
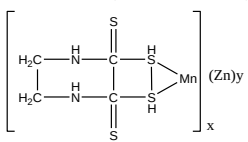
	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Highly fluorescent	Matco • Fungicide • E11-7-025	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$  Metalaxyl ($C_{15}H_{21}NO_4$) 	$\lambda_{exc.}$= 300 nm 350 ≤$\lambda_{em.}$≤ 360 nm	Δλ= 55 nm 350 ≤$\lambda_{em.}$≤ 360 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 354 nm $\lambda_{Min\text{-}point}$= 369 nm
	Ridomil Gold MZ 68 WG • Fungicide • E06-3-020	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$  Mefenoxam ($C_{15}H_{21}NO_4$) 	$\lambda_{exc.}$= 325 nm $\lambda_{em.}$≈ 390 nm	Δλ= 65 nm $\lambda_{em.}$≈ 390 nm	$\lambda_{Max\text{-}point}$= 379 nm $\lambda_{Zero\text{-}point}$= 392 nm $\lambda_{Min\text{-}point}$= 405 nm

Table 1. (Continued)

	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Highly fluorescent	Trimanoc Bleu • Fungicide • D12-6-009	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 320 nm 380 ≤$\lambda_{em.}$≤ 390 nm	Δλ= 65 nm 380 ≤$\lambda_{em.}$≤ 390 nm	$\lambda_{Max\text{-}point}$= 363 nm $\lambda_{Zero\text{-}point}$= 384 nm $\lambda_{Min\text{-}point}$= 397 nm
	Uthane 80 • Fungicide • E10-2-001	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 300 nm 350 ≤$\lambda_{em.}$≤ 360 nm	Δλ= 55 nm 350 ≤$\lambda_{em.}$≤ 360 nm	$\lambda_{Max\text{-}point}$= 336 nm $\lambda_{Zero\text{-}point}$= 356 nm $\lambda_{Min\text{-}point}$= 369 nm
Good fluorescent	Cristo MZ 80 • Fongicide • D03-6-004	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 310 nm 365 ≤$\lambda_{em.}$≤ 375 nm	Δλ= 60 nm 365 ≤$\lambda_{em.}$≤ 375 nm	$\lambda_{Max\text{-}point}$= 346 nm $\lambda_{Zero\text{-}point}$= 373 nm $\lambda_{Min\text{-}point}$= 390 nm

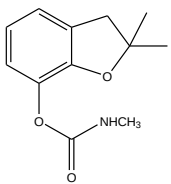
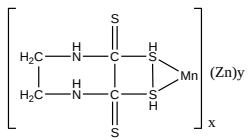
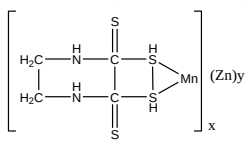
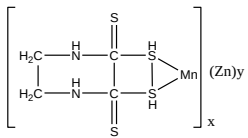
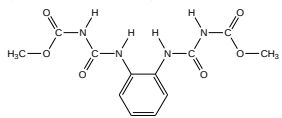
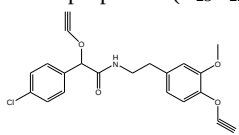
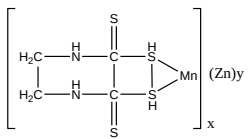
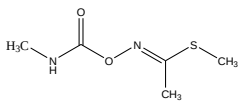
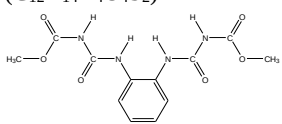
	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Good fluorescent	Axlera 5G • Insecticide • E04-6-003	Carbofuran ($C_{12}H_{15}NO_3$) 	$\lambda_{exc.}$= 290 nm $\lambda_{em.} \approx$ 340 nm	$\Delta\lambda$= 50 nm $\lambda_{em.} \approx$ 340 nm	$\lambda_{Max\text{-}point}$= 327 nm $\lambda_{Zero\text{-}point}$= 342 nm $\lambda_{Min\text{-}point}$= 353 nm
	Emthane M 45 • Fungicide • E06-3-012	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 325 nm $\lambda_{em.} \approx$ 395 nm	$\Delta\lambda$= 70 nm $\lambda_{em.} \approx$ 395 nm	$\lambda_{Max\text{-}point}$= 376 nm $\lambda_{Zero\text{-}point}$= 397 nm $\lambda_{Min\text{-}point}$= 431 nm
	Mancofil • Fungicide • E12-9-012	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 330 nm $395 \leq \lambda_{em.} \leq 405$ nm	$\Delta\lambda$= 70 nm $395 \leq \lambda_{em.} \leq 405$ nm	$\lambda_{Max\text{-}point}$= 379 nm $\lambda_{Zero\text{-}point}$= 400 nm $\lambda_{Min\text{-}point}$= 434 nm

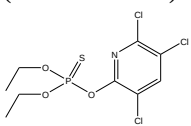
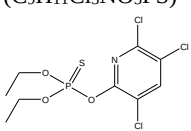
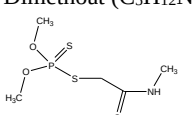
Table 1. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Good fluorescent	Manfill • Fungicide • E02-7-001	Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 330 nm 390 ≤$\lambda_{em.}$≤ 400 nm	Δλ= 65 nm 390 ≤$\lambda_{em.}$≤ 400 nm	$\lambda_{Max\text{-}point}$= 374 nm $\lambda_{Zero\text{-}point}$= 396 nm $\lambda_{Min\text{-}point}$= 410 nm
	Pelt 44 • Fungicide • 1041	Thiophanate methyl $(C_{12}H_{14}N_4O_4S_2)$ 	$\lambda_{exc.}$= 300 nm $\lambda_{em.}$≈ 355 nm	Δλ= 55 nm $\lambda_{em.}$≈ 355 nm	$\lambda_{Max\text{-}point}$= 335 nm $\lambda_{Zero\text{-}point}$= 353 nm $\lambda_{Min\text{-}point}$= 366 nm
	Pergado MZ • Fungicide • E12-9-013	Mandipropamid $(C_{23}H_{22}ClNO_4)$  Mancozeb $(C_4H_6MnN_2S_4)_x(Zn)_y$ 	$\lambda_{exc.}$= 330 nm 390 ≤$\lambda_{em.}$≤ 400 nm	Δλ= 65 nm 390 ≤$\lambda_{em.}$≤ 400 nm	$\lambda_{Max\text{-}point}$= 376 nm $\lambda_{Zero\text{-}point}$= 397 nm $\lambda_{Min\text{-}point}$= 428 nm

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Moderately fluorescent	Lannate 25 WP • Fungicide • B02-7-005	Methomyl ($C_5H_{10}N_2O_2S$) 	$\lambda_{exc.}$= 325 nm 385 ≤$\lambda_{em.}$≤ 395 nm	$\Delta\lambda$= 65 nm 385 ≤$\lambda_{em.}$≤ 395 nm	$\lambda_{Max\text{-}point}$= 373 nm $\lambda_{Zero\text{-}point}$= 389 nm $\lambda_{Min\text{-}point}$= 404 nm
	Thiogri 70 • Fungicide • B08-9-001	Thiophanate methyl ($C_{12}H_{14}N_4O_4S_2$) 	Peak I $\lambda_{exc.}$= 290 nm $\lambda_{em.}$≈ 345 nm Peak II $\lambda_{exc.}$= 355 nm 415 ≤$\lambda_{em.}$≤ 425 nm	Peak I $\Delta\lambda$= 55 nm $\lambda_{em.}$≈ 345 nm Peak II $\Delta\lambda$= 65 nm 415 ≤$\lambda_{em.}$≤ 425 nm	Peak I $\lambda_{Max\text{-}point}$= 332 nm $\lambda_{Zero\text{-}point}$= 345 nm $\lambda_{Min\text{-}point}$= 354 nm Peak II $\lambda_{Max\text{-}point}$= 407 nm $\lambda_{Zero\text{-}point}$= 418 nm $\lambda_{Min\text{-}point}$= 444 nm

* Homologation number attributed by the ONSSA (Office National de Sécurité Sanitaire des produits Alimentaires), catalog published in 2013.

Table 2. Active compounds along with TEEMs, TSFMs and FDSFS peak coordinates of Organophosphates

	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Good fluorescent	Cyren 480 EC • Insecticide • E10-2-004	Chlorpyriphos-ethyl ($C_9H_{11}Cl_3NO_3PS$) 	$\lambda_{exc.}$= 275 nm $\lambda_{em.}\approx$ 330 nm	$\Delta\lambda$= 55 nm $\lambda_{em.}\approx$ 330 nm	$\lambda_{Max\text{-}point}$= 319 nm $\lambda_{Zero\text{-}point}$= 332 nm $\lambda_{Min\text{-}point}$= 343 nm
Moderately fluorescent	Choke • Insecticide • E07-9-002	Chlorpyriphos-ethyl ($C_9H_{11}Cl_3NO_3PS$) 	Peak I $\lambda_{exc.}$= 295 nm 345 $\leq\lambda_{em.}\leq$ 355 nm Peak II $\lambda_{exc.}$= 345 nm 400 $\leq\lambda_{em.}\leq$ 410 nm	Peak I $\Delta\lambda$= 55 nm 345 $\leq\lambda_{em.}\leq$ 355 nm Peak II $\Delta\lambda$= 65 nm 400 $\leq\lambda_{em.}\leq$ 410 nm	Peak I $\lambda_{Max\text{-}point}$= 336 nm $\lambda_{Zero\text{-}point}$= 349 nm $\lambda_{Min\text{-}point}$= 361 nm Peak II $\lambda_{Max\text{-}point}$= 397 nm $\lambda_{Zero\text{-}point}$= 406 nm $\lambda_{Min\text{-}point}$= 417 nm
	Systogor 40 • Insecticide • A08-6-065	Dimethoat ($C_5H_{12}NO_3PS_2$) 	$\lambda_{exc.}$= 270 nm $\lambda_{em.}\approx$ 290 nm	$\Delta\lambda$= 20 nm $\lambda_{em.}\approx$ 290 nm	$\lambda_{Max\text{-}point}$= 280 nm $\lambda_{Zero\text{-}point}$= 289 nm $\lambda_{Min\text{-}point}$= 296 nm

* Homologation number attributed by the ONSSA (Office National de Sécurité Sanitaire des produits Alimentaires), catalog published in 2013.

Table 3. Active compounds along with TEEMs, TSFMs and FDSFS peak coordinates of Triazoles

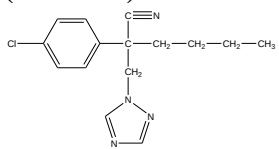
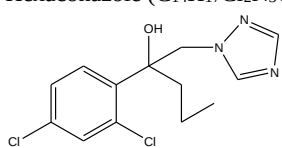
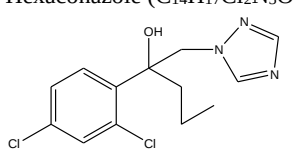
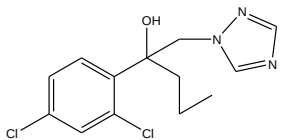
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Highly fluorescent	Boon 10 WP • Fungicide • F03-2-053	Myclobutanil ($C_{15}H_{17}ClN_4$) 	$\lambda_{exc.}$= 300 nm 350 ≤$\lambda_{em.}$≤ 360 nm	Δλ= 55 nm 350 ≤$\lambda_{em.}$≤ 360 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 355 nm $\lambda_{Min\text{-}point}$= 370 nm
	Sonazole 250 EC • Insecticide	Hexaconazole ($C_{14}H_{17}Cl_2N_3O$) 	$\lambda_{exc.}$= 280 nm $\lambda_{em.}$≈ 340 nm	Δλ= 60 nm $\lambda_{em.}$≈ 340 nm	$\lambda_{Max\text{-}point}$= 326 nm $\lambda_{Zero\text{-}point}$= 338 nm $\lambda_{Min\text{-}point}$= 349 nm
Good fluorescent	Orsalis 5% SC • Fungicide • E11-6-010	Hexaconazole ($C_{14}H_{17}Cl_2N_3O$) 	$\lambda_{exc.}$= 275 nm $\lambda_{em.}$≈ 305 nm	Δλ= 30 nm $\lambda_{em.}$≈ 305 nm	$\lambda_{Max\text{-}point}$= 298 nm $\lambda_{Zero\text{-}point}$= 307 nm $\lambda_{Min\text{-}point}$= 315 nm

Table 3. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Moderately fluorescent	Hexa 5 SC • Insecticide • E07-5-009	Hexaconazole ($C_{14}H_{17}Cl_2N_3O$) 	Peak I $\lambda_{exc.}$= 320 nm 425 ≤$\lambda_{em.}$≤ 435 nm Peak II $\lambda_{exc.}$= 275 nm $\lambda_{em.}$≈ 310 nm	Peak I Δλ= 110 nm 425 ≤$\lambda_{em.}$≤ 435 nm Peak II Δλ= 35 nm $\lambda_{em.}$≈ 310 nm	Peak I $\lambda_{Max\text{-}point}$= 420 nm $\lambda_{Zero\text{-}point}$= 432 nm $\lambda_{Min\text{-}point}$= 446 nm Peak II $\lambda_{Max\text{-}point}$= 298 nm $\lambda_{Zero\text{-}point}$= 309 nm $\lambda_{Min\text{-}point}$= 319 nm

* Homologation number attributed by the ONSSA (Office National de Sécurité Sanitaire des produits Alimentaires), catalog published in 2013.

Table 4. Active compounds along with TEEMs, TSFMs and FDSFS peak coordinates of Pyrethrinoids and Minerals

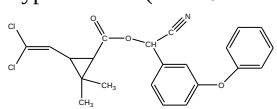
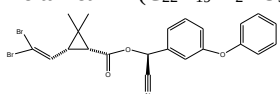
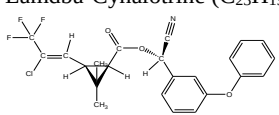
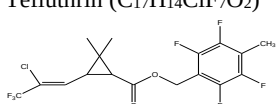
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Highly fluorescent	Cyrux • Insecticide • E12-4-008	Cypermethrin ($C_{22}H_{19}Cl_2NO_3$) 	$\lambda_{exc.}$= 275 nm $\lambda_{em.} \approx$ 300 nm	$\Delta\lambda$= 25 nm $\lambda_{em.} \approx$ 300 nm	$\lambda_{Max\text{-}point}$= 292 nm $\lambda_{Zero\text{-}point}$= 302 nm $\lambda_{Min\text{-}point}$= 311 nm
	Megasulph • Fungicide • E11-9-013	Sulfur (S_x)	$\lambda_{exc.}$= 300 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\Delta\lambda$= 55 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\lambda_{Max\text{-}point}$= 336 nm $\lambda_{Zero\text{-}point}$= 356 nm $\lambda_{Min\text{-}point}$= 370 nm
	Sulphur 80% WG • Fungicide • E05-8-003	Sulfur (S_x)	$\lambda_{exc.}$= 300 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\Delta\lambda$= 55 nm 350 $\leq\lambda_{em.}\leq$ 360 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 357 nm $\lambda_{Min\text{-}point}$= 371 nm
Good fluorescent	Copas • Fungicide • E07-9-024	Copper-sulfate copper	$\lambda_{exc.}$= 295 nm 345 $\leq\lambda_{em.}\leq$ 355 nm	$\Delta\lambda$= 55 nm 345 $\leq\lambda_{em.}\leq$ 355 nm	$\lambda_{Max\text{-}point}$= 334 nm $\lambda_{Zero\text{-}point}$= 348 nm $\lambda_{Min\text{-}point}$= 360 nm
	Microlus Super • Fungicide • E12-7-020	Sulfur (S_x)	$\lambda_{exc.}$= 335 nm 395 $\leq\lambda_{em.}\leq$ 405 nm	$\Delta\lambda$= 65 nm 395 $\leq\lambda_{em.}\leq$ 405 nm	$\lambda_{Max\text{-}point}$= 375 nm $\lambda_{Zero\text{-}point}$= 401 nm $\lambda_{Min\text{-}point}$= 424 nm

Table 4. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Good fluorescent	Super Coloss • Fungicide • B10-9-002	Copper-sulfate copper	$\lambda_{exc.}$= 295 nm $\lambda_{em.}\approx$ 350 nm	$\Delta\lambda$= 55 nm $\lambda_{em.}\approx$ 350 nm	$\lambda_{Max\text{-}point}$= 335 nm $\lambda_{Zero\text{-}point}$= 350 nm $\lambda_{Min\text{-}point}$= 362 nm
	Decis EC 25 EC • Insecticide	Deltamethrin ($C_{22}H_{19}Br_2NO_3$) 	$\lambda_{exc.}$= 275 nm $\lambda_{em.}\approx$ 300 nm	$\Delta\lambda$= 25 nm $\lambda_{em.}\approx$ 300 nm	$\lambda_{Max\text{-}point}$= 288 nm $\lambda_{Zero\text{-}point}$= 297 nm $\lambda_{Min\text{-}point}$= 305 nm
	Pulsar • Insecticide • E02-8-004	Lamdba-Cyhalotrine ($C_{23}H_{19}ClF_3NO_3$) 	$\lambda_{exc.}$= 275 nm $\lambda_{em.}\approx$ 300 nm	$\Delta\lambda$= 25 nm $\lambda_{em.}\approx$ 300 nm	$\lambda_{Max\text{-}point}$= 289 nm $\lambda_{Zero\text{-}point}$= 298 nm $\lambda_{Min\text{-}point}$= 306 nm
Moderately fluorescent	Cobox • Fungicide • 0485	Copper oxychloride ($ClCu_2H_3O_3$)	$\lambda_{exc.}$= 320 nm $\lambda_{em.}\approx$ 385 nm	$\Delta\lambda$= 65 nm $\lambda_{em.}\approx$ 385 nm	$\lambda_{Max\text{-}point}$= 372 nm $\lambda_{Zero\text{-}point}$= 386 nm $\lambda_{Min\text{-}point}$= 400 nm
	Force 0.5 G • Insecticide • E07-9-003	Tefluthrin ($C_{17}H_{14}ClF_7O_2$) 	$\lambda_{exc.}$= 280 nm $\lambda_{em.}\approx$ 350 nm	$\Delta\lambda$= 70 nm $\lambda_{em.}\approx$ 350 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 352 nm $\lambda_{Min\text{-}point}$= 363 nm

* Homologation number attributed by the ONSSA (Office National de Sécurité Sanitaire des produits Alimentaires), catalog published in 2013.

Table 5. Active compounds along with TEEMs, TSFMs and FDSFS peak coordinates of non-assigned pesticides

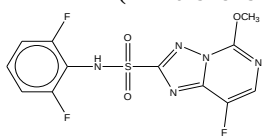
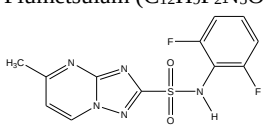
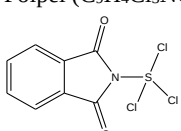
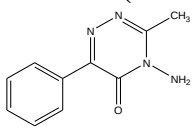
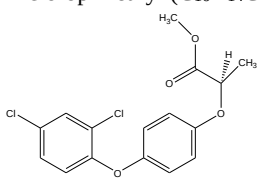
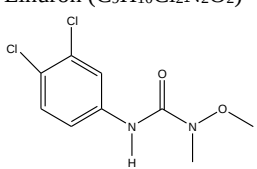
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Highly fluorescent	Derby 175 SC • Insecticide • E01-0-002	Florasulam ($C_{12}H_8F_3N_5O_3S$)  Flumetsulam ($C_{12}H_9F_2N_5O_2S$) 	$\lambda_{exc.}$= 300 nm $\lambda_{em.}\approx$ 350 nm	$\Delta\lambda$= 50 nm $\lambda_{em.}\approx$ 350 nm	$\lambda_{Max\text{-}point}$= 341 nm $\lambda_{Zero\text{-}point}$= 352 nm $\lambda_{Min\text{-}point}$= 363 nm
	Foltax 50 WP • Fungicide • D12-8-008	Folpel ($C_9H_4Cl_3NO_2S$) 	$\lambda_{exc.}$= 295 nm 345 $\leq\lambda_{em.}\leq$ 355 nm	$\Delta\lambda$= 55 nm 345 $\leq\lambda_{em.}\leq$ 355 nm	$\lambda_{Max\text{-}point}$= 338 nm $\lambda_{Zero\text{-}point}$= 351 nm $\lambda_{Min\text{-}point}$= 364 nm
	Golden Mirowet • adjuvant Wetting • B12-1-001	Nonyl phenol polyglycol ether	$\lambda_{exc.}$= 280 nm $\lambda_{em.}\approx$ 305 nm	$\Delta\lambda$= 25 nm $\lambda_{em.}\approx$ 305 nm	$\lambda_{Max\text{-}point}$= 294 nm $\lambda_{Zero\text{-}point}$= 303 nm $\lambda_{Min\text{-}point}$= 311 nm

Table 5. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Highly fluorescent	Goltix 90 WG • Herbicide • F06-0-049	Metamitron ($C_{10}H_{10}N_4O$) 	$\lambda_{exc.}$= 325 nm $\lambda_{em.}\approx$ 385 nm	$\Delta\lambda$= 60 nm $\lambda_{em.}\approx$ 385 nm	$\lambda_{Max\text{-}point}$= 373 nm $\lambda_{Zero\text{-}point}$= 385 nm $\lambda_{Min\text{-}point}$= 398 nm
	Illoxan 36 CE • Herbicide • B08-0-001	Diclofop-methyl ($C_{16}H_{14}Cl_2O_4$) 	$\lambda_{exc.}$= 300 nm $\lambda_{em.}\approx$ 360 nm	$\Delta\lambda$= 60 nm $\lambda_{em.}\approx$ 360 nm	$\lambda_{Max\text{-}point}$= 349 nm $\lambda_{Zero\text{-}point}$= 359 nm $\lambda_{Min\text{-}point}$= 369 nm
	Lafaloune • Herbicide • A04-6-035	Linuron ($C_9H_{10}Cl_2N_2O_2$) 	$\lambda_{exc.}$= 290 nm $\lambda_{em.}\approx$ 345 nm	$\Delta\lambda$= 55 nm $\lambda_{em.}\approx$ 345 nm	$\lambda_{Max\text{-}point}$= 333 nm $\lambda_{Zero\text{-}point}$= 347 nm $\lambda_{Min\text{-}point}$= 360 nm

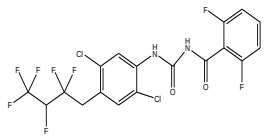
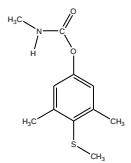
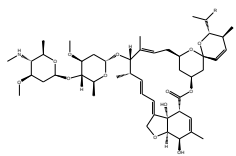
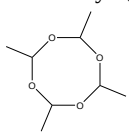
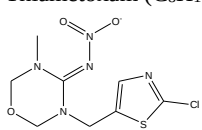
	Commercial name Category Homologation number*	Active compound(s) and Chemical formula(s)	TEEMs	TSFMs	FDSFS
Highly fluorescent	Match 050 EC • Insecticide • E11-0-005	Lufenuron ($C_{17}H_8Cl_2F_8N_2O_3$) 	Peak I $\lambda_{exc.}$= 290 nm 340 ≤$\lambda_{em.}$≤ 350 nm Peak II $\lambda_{exc.}$= 310 nm 430 ≤$\lambda_{em.}$≤ 440 nm	Peak I Δλ= 55 nm 340 ≤$\lambda_{em.}$≤ 350 nm Peak II Δλ= 125 nm 430 ≤$\lambda_{em.}$≤ 440 nm	Peak I $\lambda_{Max\text{-}point}$= 328 nm $\lambda_{Zero\text{-}point}$= 347 nm $\lambda_{Min\text{-}point}$= 361 nm Peak II $\lambda_{Max\text{-}point}$= 415 nm $\lambda_{Zero\text{-}point}$= 434 nm $\lambda_{Min\text{-}point}$= 449 nm
	Mesurol 50 WP • Insecticide • 1010	Mercaptodimethur ($C_{11}H_{15}NO_2S$) 	$\lambda_{exc.}$= 295 nm $\lambda_{em.}$≈ 350 nm	Δλ= 55 nm $\lambda_{em.}$≈ 350 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 351 nm $\lambda_{Min\text{-}point}$= 363 nm
	Proclaim 05 SG • Fungicide • E05-5-002	Emamectin benzoate 	$\lambda_{exc.}$= 295 nm $\lambda_{em.}$≈ 345 nm	Δλ= 50 nm $\lambda_{em.}$≈ 345 nm	$\lambda_{Max\text{-}point}$= 329 nm $\lambda_{Zero\text{-}point}$= 343 nm $\lambda_{Min\text{-}point}$= 353 nm

Table 5. (Continued)

	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Good fluorescent	Ghlala • Molluscicide • B09-3-001	Metaldehyd ($C_8H_{16}O_4$) 	Peak I $\lambda_{exc.}$= 285 nm 350 ≤$\lambda_{em.}$≤ 360 nm Peak II $\lambda_{exc.}$= 360 nm 465 ≤$\lambda_{em.}$≤ 475 nm	Peak I Δλ= 70 nm 350 ≤$\lambda_{em.}$≤ 360 nm Peak II Δλ= 110 nm 465 ≤$\lambda_{em.}$≤ 475 nm	Peak I $\lambda_{Max\text{-}point}$= 342 nm $\lambda_{Zero\text{-}point}$= 354 nm $\lambda_{Min\text{-}point}$= 365 nm Peak II $\lambda_{Max\text{-}point}$= 455 nm $\lambda_{Zero\text{-}point}$= 467 nm $\lambda_{Min\text{-}point}$= 470 nm
	Actara 25 WG • Insecticide • D09-9-002	Thiametoxam ($C_8H_{10}ClN_5O_3S$) 	Peak I $\lambda_{exc.}$= 515 nm $\lambda_{em.}$≈ 540 nm Peak II $\lambda_{exc.}$= 325 nm $\lambda_{em.}$≈ 405 nm	Peak I Δλ= 25 nm $\lambda_{em.}$≈ 540 nm Peak I Δλ= 80 nm $\lambda_{em.}$≈ 405 nm	Peak I $\lambda_{Max\text{-}point}$= 528 nm $\lambda_{Zero\text{-}point}$= 538 nm $\lambda_{Min\text{-}point}$= 549 nm Peak II $\lambda_{Max\text{-}point}$= 387 nm $\lambda_{Zero\text{-}point}$= 405 nm $\lambda_{Min\text{-}point}$= 419 nm

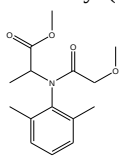
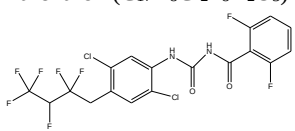
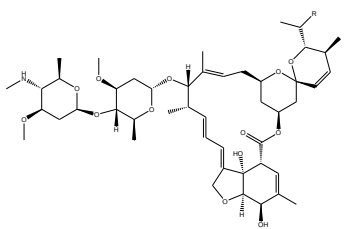
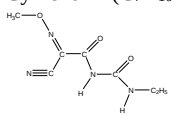
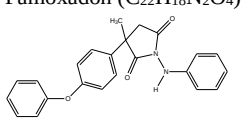
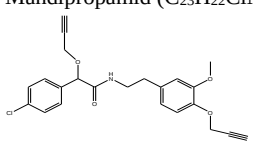
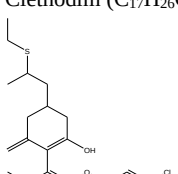
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Good fluorescent	Cyclo Drop • Fungicide • E11-4-01	Metalaxyl ($C_{15}H_{21}NO_4$) 	$\lambda_{exc.}$= 300 nm 350 ≤$\lambda_{em.}$≤ 360 nm	Δλ= 55 nm 350 ≤$\lambda_{em.}$≤ 360 nm	$\lambda_{Max\text{-}point}$= 337 nm $\lambda_{Zero\text{-}point}$= 356 nm $\lambda_{Min\text{-}point}$= 369 nm
	Denim Fit • Insecticide • E12-9-036	Lufenuron ($C_{17}H_8Cl_2F_8N_2O_3$)  Emamectin benzoate 	$\lambda_{exc.}$= 330 nm 395 ≤$\lambda_{em.}$≤ 405 nm	Δλ= 70 nm 395 ≤$\lambda_{em.}$≤ 405 nm	$\lambda_{Max\text{-}point}$= 379 nm $\lambda_{Zero\text{-}point}$= 400 nm $\lambda_{Min\text{-}point}$= 433 nm

Table 5. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Good fluorescent	Equation Pro • Fungicide • D12-7-004	Cymoxanil ($C_7H_{10}N_4O_3$)  Famoxadon ($C_{22}H_{18}N_2O_4$) 	$\lambda_{exc.}$= 290 nm 335 ≤$\lambda_{em.}$≤ 345 nm	Δλ= 50 nm 335 ≤$\lambda_{em.}$≤ 345 nm	$\lambda_{Max\text{-}point}$= 328 nm $\lambda_{Zero\text{-}point}$= 342 nm $\lambda_{Min\text{-}point}$= 351 nm
	Revus MZ 65 WG • Fungicide • E11-7-039	Mandipropamid ($C_{23}H_{22}ClNO_4$) 	$\lambda_{exc.}$= 335 nm 395 ≤$\lambda_{em.}$≤ 405 nm	Δλ= 65 nm 395 ≤$\lambda_{em.}$≤ 405 nm	$\lambda_{Max\text{-}point}$= 378 nm $\lambda_{Zero\text{-}point}$= 399 nm $\lambda_{Min\text{-}point}$= 428 nm
	Select Super • Herbicide • E05-1-006	Clethodim ($C_{17}H_{26}ClNO_3S$) 	Peak I $\lambda_{exc.}$= 275 nm $\lambda_{em.}$≈ 330 nm Peak II $\lambda_{exc.}$= 380 nm $\lambda_{em.}$≈ 450 nm	Peak I Δλ= 55 nm $\lambda_{em.}$≈ 330 nm Peak II Δλ= 70 nm $\lambda_{em.}$≈ 450 nm	Peak I $\lambda_{Max\text{-}point}$ = 319 nm $\lambda_{Zero\text{-}point}$= 331 nm $\lambda_{Min\text{-}point}$= 343 nm Peak II $\lambda_{Max\text{-}point}$= 437 nm $\lambda_{Zero\text{-}point}$= 451 nm $\lambda_{Min\text{-}point}$= 471 nm

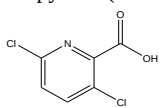
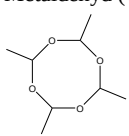
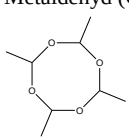
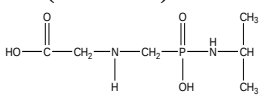
	Commercial name **Category** **Homologation number***	**Active compound(s) and chemical formula(s)**	**TEEMs**	**TSFMs**	**FDSFS**
Moderately fluorescent	Lontrel 100 SL • Herbicide • F11-0-046	Clopyralid ($C_6H_3Cl_2NO_2$) 	Peak I $\lambda_{exc.}$= 335 nm 435 ≤$\lambda_{em.}$≤ 445 nm Peak II $\lambda_{exc.}$= 325 nm 395 ≤$\lambda_{em.}$≤ 405 nm	Peak I Δλ= 105 nm 435 ≤$\lambda_{em.}$≤ 445 nm Peak II Δλ= 75 nm 395 ≤$\lambda_{em.}$≤ 405 nm	Peak I $\lambda_{Max\text{-}point}$ = 404 nm $\lambda_{Zero\text{-}point}$= 442 nm $\lambda_{Min\text{-}point}$= 478 nm Peak II $\lambda_{Max\text{-}point}$= 382 nm $\lambda_{Zero\text{-}point}$= 402 nm $\lambda_{Min\text{-}point}$= 412 nm
	Appariol • Molluscicide	Metaldehyd ($C_8H_{16}O_4$) 	Peak I $\lambda_{exc.}$= 285 nm 355 ≤$\lambda_{em.}$≤ 365 nm Peak II $\lambda_{exc.}$= 340 nm 425 ≤$\lambda_{em.}$≤ 435 nm	Peak I Δλ= 75 nm 355 ≤$\lambda_{em.}$≤ 365 nm Peak II Δλ= 90 nm 425 ≤$\lambda_{em.}$≤ 435 nm	Peak I $\lambda_{Max\text{-}point}$= 344 nm $\lambda_{Zero\text{-}point}$= 358 nm $\lambda_{Min\text{-}point}$= 369 nm Peak II $\lambda_{Max\text{-}point}$= 409 nm $\lambda_{Zero\text{-}point}$= 429 nm $\lambda_{Min\text{-}point}$= 448 nm
	Bourgui • Molluscicide	Metaldehyd ($C_8H_{16}O_4$) 	Peak I $\lambda_{exc.}$= 355 nm 460 ≤$\lambda_{em.}$≤ 470 nm Peak II $\lambda_{exc.}$= 285 nm 355 ≤$\lambda_{em.}$≤ 365 nm	Peak I Δλ= 110 nm 460 ≤$\lambda_{em.}$≤ 470 nm Peak II Δλ= 75 nm 355 ≤$\lambda_{em.}$≤ 365 nm	Peak I $\lambda_{Max\text{-}point}$= 448 nm $\lambda_{Zero\text{-}point}$= 465 nm $\lambda_{Min\text{-}point}$= 490 nm Peak II $\lambda_{Max\text{-}point}$= 347 nm $\lambda_{Zero\text{-}point}$= 360 nm $\lambda_{Min\text{-}point}$= 368 nm

Table 5. (Continued)

	Commercial name Category Homologation number*	Active compound(s) and chemical formula(s)	TEEMs	TSFMs	FDSFS
Moderately fluorescent	Glyweed • Herbicide • E11-7-051	Glyphosateisopropylamine(IPA) Salt ($C_3H_8NO_5P$) 	$\lambda_{exc.}$= 425 nm 475 ≤$\lambda_{em.}$≤ 485 nm	Δλ= 55 nm 475 ≤$\lambda_{em.}$≤ 485 nm	$\lambda_{Max\text{-}point}$= 463 nm $\lambda_{Zero\text{-}point}$= 479 nm $\lambda_{Min\text{-}point}$= 498 nm
	Herboxone • Herbicide • E05-1-009	2.4-D amine salt	$\lambda_{exc.}$= 315 nm $\lambda_{em.}$≈ 430 nm	Δλ= 115 nm $\lambda_{em.}$≈ 430 nm	$\lambda_{Max\text{-}point}$= 417 nm $\lambda_{Zero\text{-}point}$= 432 nm $\lambda_{Min\text{-}point}$= 445 nm
	Lieli 2000 • Fungicide	Phosphorus (P), Phosphorus (P), Potassium (K), Organic Matter, Seaweed Extract, Alginic Acid	$\lambda_{exc.}$= 360 nm 435 ≤$\lambda_{em.}$≤ 445 nm	Δλ= 80 nm 435 ≤$\lambda_{em.}$≤ 445 nm	$\lambda_{Max\text{-}point}$= 401 nm $\lambda_{Zero\text{-}point}$= 439 nm $\lambda_{Min\text{-}point}$= 464 nm
	Menjel 24 EC • Herbicide • D01-4-004	2.4-D -ester butylglycol	$\lambda_{exc.}$= 290 nm $\lambda_{em.}$≈ 350 nm	Δλ= 60 nm $\lambda_{em.}$≈ 350 nm	$\lambda_{Max\text{-}point}$= 332 nm $\lambda_{Zero\text{-}point}$= 350 nm $\lambda_{Min\text{-}point}$= 361 nm

* Homologation number attributed by the ONSSA (Office National de Sécurité Sanitaire des produits Alimentaires), catalog published in 2013.

In all fields the soil samples were taken on diverse points, at a depth of about 5-10 cm from the surface, intermixed and then stored in freezer bags at a temperature of about 15 °C. 20 grams of each stored soil were mixed in 40 ml of water, taken as extracting medium, and stirred for 60 min to activate the dissolution of any pesticide remains into the extracting water. The water-soil mixture was kept for 24 to 72 h to decant without any filtration procedure; the final extracts showed pH values around 8. The water extract top layer was then put into the quartz cell of the spectrometer. On average, the fluorescence/absorption measurements were carried out one week after sampling.

Detection and Identification of Pesticide Remains in Soils

Figures 1-4_b report the TEEMs, TSFMs and optimal SFS, combined with their first derivatives, recorded on the water extracts obtained from the pre-treated soil samples described above. These maps and spectra are presented in comparison with those recoded directly on the targeted pesticides dissolved in water (Figures 1-4_a) and those recorded on the water extract prepared with the non-treated soil sample (Figures 1-4_c).

The maps and spectra corresponding to the non-treated soil (Figures 1-4_c) show only the features related to the soil natural organic matter (NOM); in the literature these features are typically extended in the ranges 320-380 nm in excitation and 420-500 nm in emission Zhao (2011) and Luciani et al. (2008). On the contrary, the maps and spectra corresponding to the pre-treated soils (Figures 1-4_b) show characteristics perfectly matching those observed on the dissolved pesticides (Figures 1-4_a); the added solid arrows inter-connect these features.

The NOM peaks are also present on TEEMs, TSFMs and SFS recorded on the water extracts of the pre-treated soils. In the case of the soil pretreated by the herbicide Betanal Expert 274 C, only the signal of the pesticide is observed Figure 1_b. Indeed, Betanal Expert is a highly fluorescent mixture; the corresponding signal hid completely the NOM fluorescence. Contrary to this, in the case of the soil pretreated by the moderately fluorescent Lontrel 100 SL the fluorescence signal originating from the NOM overlapped without hiding the fluorescence signal of the

pesticide (Figure 4_b). The added dashed arrows inter-match the NOM features between the maps. The offsets $\Delta\lambda$ (= $\lambda_{em.}$–$\lambda_{exc.}$) shown on the synchronous fluorescence spectra (SFS) are those at which the pesticide exhibits its highest fluorescence signals. The knowledge of these values allows detecting and recognizing the pesticide alone or in a mixture of fluorescent compounds.

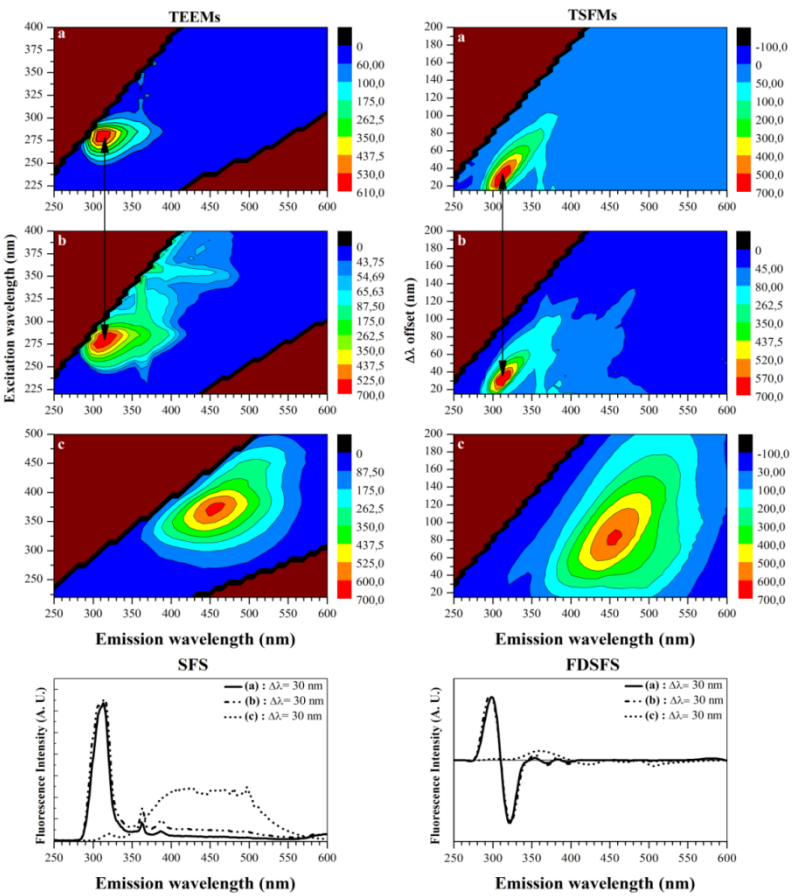


Figure 1. TEE and TSF maps along with SFS and FDSFS recorded at $\Delta\lambda$ = 30 nm offset for: (a) the commercial Carbamate Betanal Expert 274 EC (herbicide) dissolved in water at C = 10^{-4} ml/ml, (b) the water extract obtained from the soil sampled on the sugar beet field pre-treated by Betanal Expert 274 EC and (c) the water extract obtained from the soil sampled on the non-treated field. The solid arrows connect the recovered peaks of Betanal Expert 274 EC.

The performed applicability tests show that all optical fingerprints of the targeted pesticides are well recovered on the TEE and TSF matrices established for the soils sampled in the pre-treated lands. This recovery confirms clearly the contamination of the soils by the commercial pesticide remains.

From these four applicability tests performed, it can then be drawn that the present assay met the purpose of a rapid and low-cost monitoring of agricultural soils by detecting remains of pesticides.

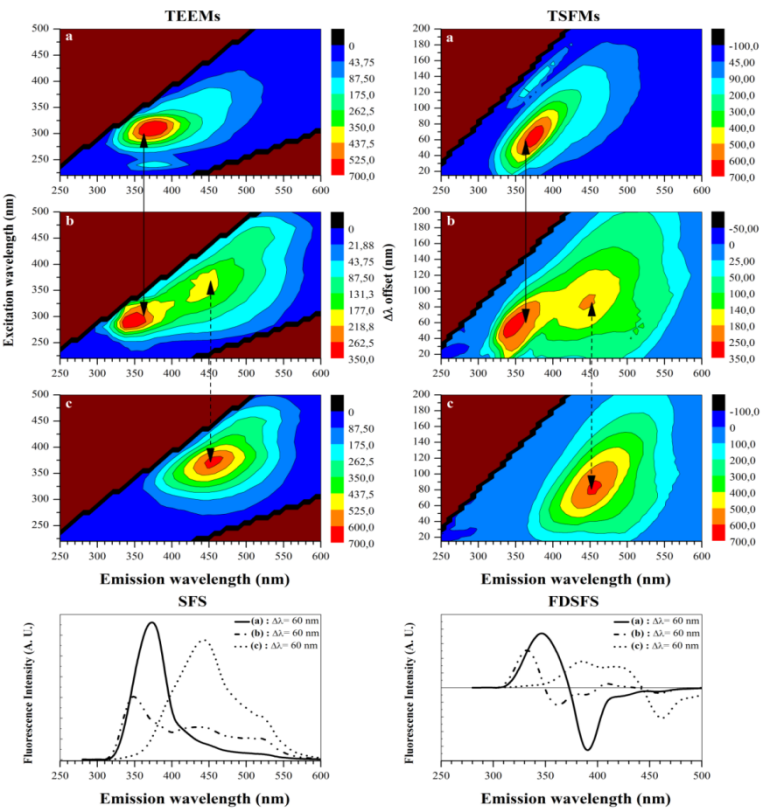


Figure 2. TEE and TSF maps along with SFS and FDSFS recorded at $\Delta\lambda$ = 60 nm offset for: (a) the commercial Thiocarbamate Cristo MZ 80 (fungicide) dissolved in water at C = 2.5 × 10^{-4} g/ml, (b) the water extract obtained from the soil sampled on the potato field pre-treated by Cristo MZ 80 and (c) the water extract obtained from the soil sampled on the non-treated field. The solid arrows connect the recovered peaks of Cristo MZ 80, the dashed ones connect the peaks of the soils NOM.

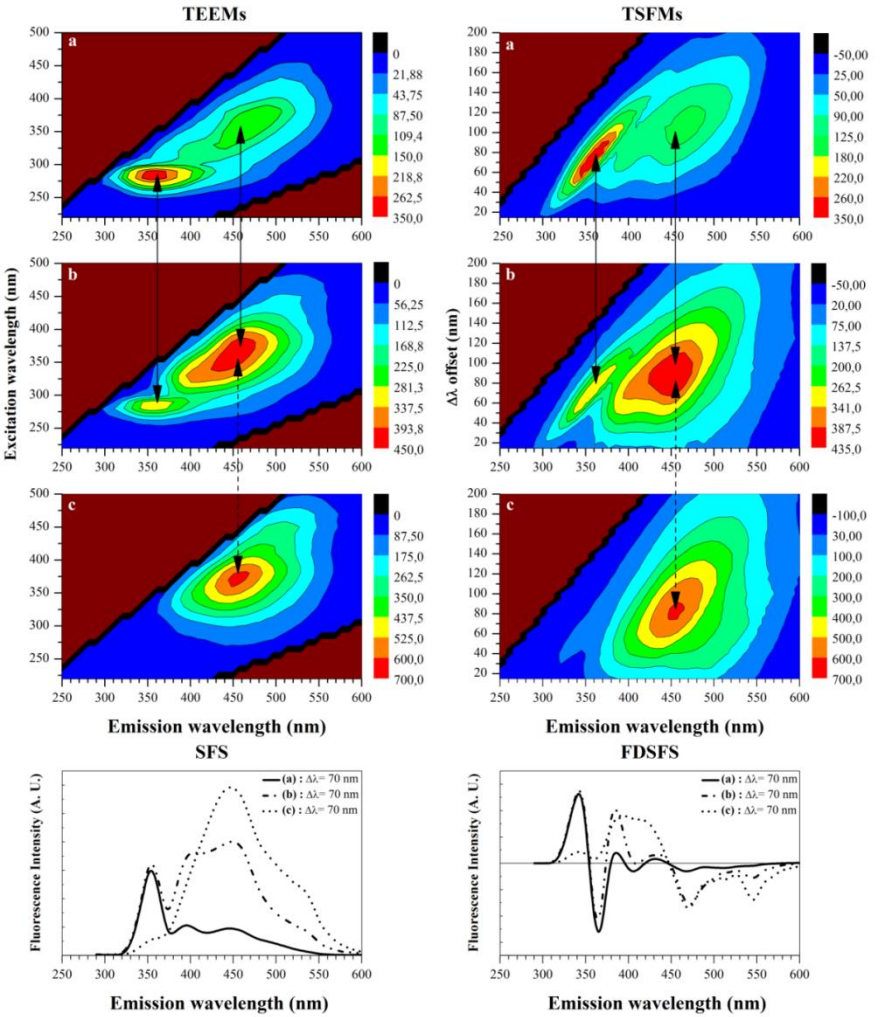


Figure 3. TEE and TSF maps along with SFS and FDSFS recorded at Δλ = 70 nm offset for: (a) the commercial Cyclo-octane Ghlala (molluscicide) dissolved in water at C = 10^{-3} g/ml, (b) the water extract obtained from the soil sampled on the sugar beet field pre-treated by Ghlala and (c) the water extract obtained from the soil sampled on the non-treated field. The solid arrows connect the recovered peaks of Ghlala, the dashed ones connect the peaks of the soils NOM.

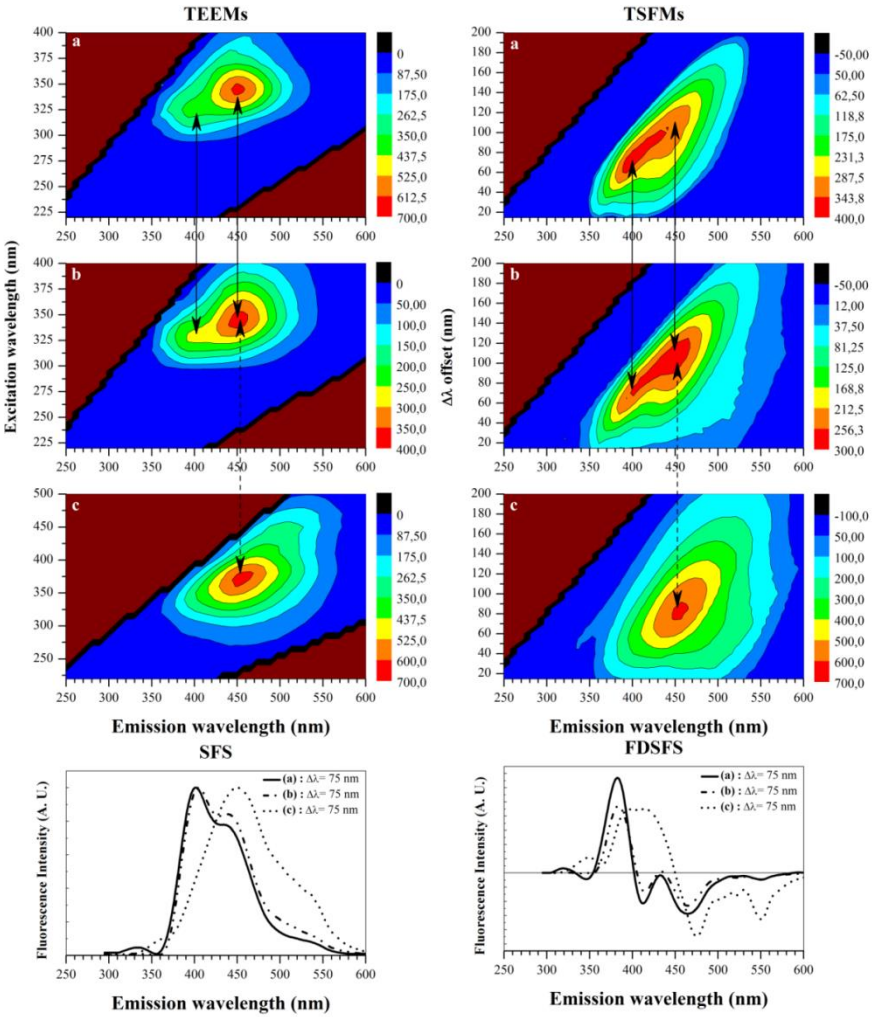


Figure 4. TEE and TSF maps along with SFS and FDSFS recorded at Δλ = 75 nm offset for: (a) the commercial Picolinic acid Lontrel 100 SL (herbicide) dissolved in water at C = 10^{-3} ml/ml, (b) the water extract obtained from the soil sampled on the sugar beet field pre-treated by Lontrel 100 SL and (c) the water extract obtained from the soil sampled on the non-treated field. The solid arrows connect the recovered peaks of Lontrel 100 SL, the dashed ones connect the peaks of the soils NOM.

Data Analysis

As it can be observed on TEEMs, TSFMs and optimal SFS, many pesticides give fluorescence signals in a same emission wavelength range in spite of their belonging to completely different chemical families. This behavior, making uncomfortable interpretation of data, may be explained by suspension matrices similarity; these latter constitute probably the fluorescing species in the commercial pesticide mixtures. Consequently, to obtain data bearing relevant information on the developed analysis approach, a statistical analysis combining results of all excitation-emission and synchronous fluorescence measurements has been considered. The purpose is to reach criteria allowing to state about the discrimination between different emitting pesticides coexisting in a same soil or water sample. On the basis of a Principal Component Analysis (PCA) approach, a statistical exploration of all obtained excitation-emission and synchronous fluorescence characteristics, of the present representative set of pesticides, has been carried out. PCA, is a helpful method to reduce and cluster data variability of samples, it has been applied in many topics (Alberghina et al. 2014; Ren et al. 2015). The principle of this statistical technique consists in reducing data dimensionality by mean of transforming the original data set to a new uncorrelated set of variables, called Principal Components (PCs) or Factors (Fs). These factors are combinations of the original variables and are uncorrelated; they are obtained as eigenvectors of the correlation matrix.

In the present case, in order to take into account all the main spectral characteristics of the fingerprinted pesticides, the original variables introduced in the software are: the offset $\Delta\lambda$ ($\Delta\lambda = \lambda_{em.} - \lambda_{exc.}$), λ_{max}, λ_{min} and λ_0. $\Delta\lambda$ is the optimal offset at which the synchronous fluorescence spectrum is carried out while λ_{max}, λ_0 and λ_{min} represent the wavelength values in nm at which the first derivative of the synchronous fluorescence spectrum shows respectively its maximum, zero-point and minimum. Note that the zero-point wavelength corresponds also to the maximum wavelength on the synchronous fluorescence spectrum at the offset $\Delta\lambda$; it coincides also with the main emission peaks on both of TEE and TSF

maps. Hence the variables chosen in this statistical analysis contain information on all the spectroscopic features observed on each pesticide.

The diagonalization of the correlation matrix of the four initial variables led to four eigenvalues and four eigenvectors i.e., new variables F_i (i=1, 2, 3, 4); the individuals are the pesticides. Table 6 shows the obtained eigenvalues along with the relative and cumulative variances. It can be noticed that the first two factors explain 99% of the total variance, reflecting thus the most of the whole samples information.

Table 6. Total variance explained: Relative and cumulative variances

Component	Initial eigenvalues		
	Eigenvalues	% of variance	% of cumulative variance
1	3.704	92.593	92.593
2	0.273	6.816	99.409
3	0.021	0.530	99.939
4	0.002	0.061	100.000

As can be seen on Figure 5, the first factor F_1 is highly and positively correlated with all the old variables, while F_2 is fairly correlated with the offset $\Delta\lambda$ and weakly correlated with the other variables. All these observations, made on the correlation between the new factors and the old variables, lead to the assumption that the offset $\Delta\lambda$, at which is recorded the synchronous fluorescence spectrum, constitutes the most discriminative variable between pesticide entities. This is not surprising in so far as synchronous fluorescence is always adopted in the analysis of fluorescent mixtures.

On Figure 6 are represented the fingerprinted pesticides as individuals in the (F_1, F_2) plane. The main remark that can be made is the alignment of pesticides appearing at a same optimal offset. Hence we can observe lines of pesticides at 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110 and 115 nm offsets. Since many pesticides appear at close offsets and close emission wavelengths, we have calculated the squares of the distances (d^2) between pesticides in the main plane (F_1, F_2). These calculated values range between zero and 55. After a thorough comparison

between the spectra and matrices of all the characterized pesticides, we emitted the statement that any arbitrary pesticides coexisting in a same mixture can be discriminated on a TEEM, TSFM or SFS, only if they are distant by a distance d presenting a square value d^2 superior to 0.25. Otherwise, if the d^2 value is inferior or equal to 0.25 the fluorescence bands of the emitting pesticides will overlap each other, leading thus to a more or less large signal. Consequently, while analyzing a real water sample, at a given offset Δλ, the synchronous fluorescence spectrum might show signals attributable to groups of non-discriminable emitting chemicals, and signals attributable to discriminable ones. In the present study, the groups of non-discriminable pesticides are gathered in Table 7. Furthermore, from Figure 6, it can be noticed that the large majority of the investigated chemicals are observed in the offset range [50-70] nm and are emitting in the wavelength intervals 345 ± 15 nm or 390 ± 10 nm.

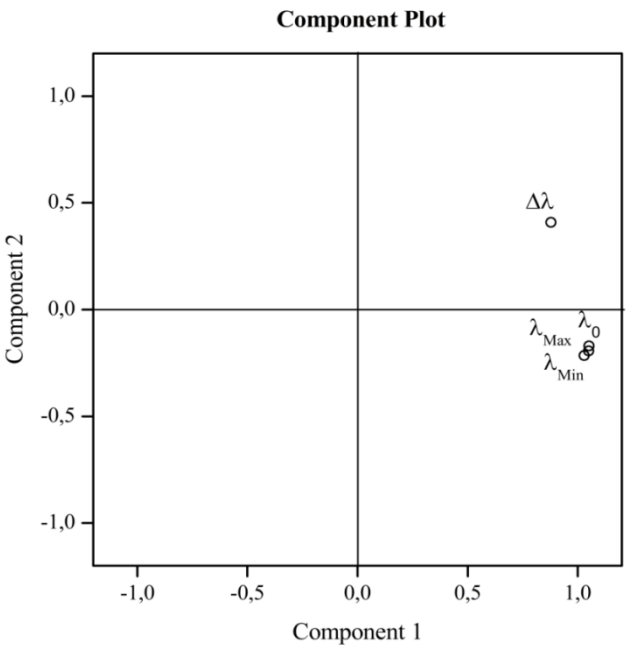


Figure 5. Component plot: correlation between the new factors F_1 and F_2 and the original variables.

Table 7. Groups of non-discriminable pesticides

G1:	Δλ= 25 ± 5 nm λ0= 300 ± 10 nm		G2:	Δλ= 55 ± 5 nm λ0= 345 ± 15 nm		G3:	Δλ= 65 ± 5 nm λ0= 390 ± 10 nm	
Pesticides	Δλ	λ0	Pesticides	Δλ	λ0	Pesticides	Δλ	λ0
Systogor 40	20	289	Axlera 5 G	50	342	Goltix 9O WG	60	385
Cyrux	25	302	Equation Pro	50	342	Lannate 25 WP	65	389
Decis EC 25 EC	25	297	Proclaim 05 SG	50	343	Manfill	65	396
Pulsar	25	298	Choke	55	349	Pergado MZ	65	397
Golden	25	303	Boon 10 WP	55	355	Ridomil Gold MZ 68 WG	65	392
Orsalis 5% SC	30	307	Agrizeb 80 WP	55	350			
			Fantic M	55	354	Trimanoc Bleu	65	384
			Matco	55	354	Cobox	65	386
			Pelt 44	55	353	Microlus Super	65	401
			Thiogri 1	55	345	Revus MZ 65 WG	65	399
			Copas	55	348	Emthane M 45	70	397
			Megasulph	55	356	Mancofil	70	400
			Sulphur 80% WG	55	357	Denim Fit	70	400
			Super Coloss	55	350	**G4:**	**Δλ= 75 ± 5 nm λ0= 360 ± 10 nm**	
			Cyclo Drop	55	356			
			Foltax 50 WP	55	351			
			Lafaloune	55	347	Force 0,5 G	70	352
			Match 050 EC	55	347	Appariol	75	358
			Mesurol 50 WP	55	351	**G5:**	**Δλ= 115 ± 5 nm λ0= 430 ± 10 nm**	
			Sonazole 250 EC	60	335			
			Illoxan 36 CE	60	359	Hexa 5 SC	110	432
			Menjel 24 EC	60	350	Herboxone	115	432

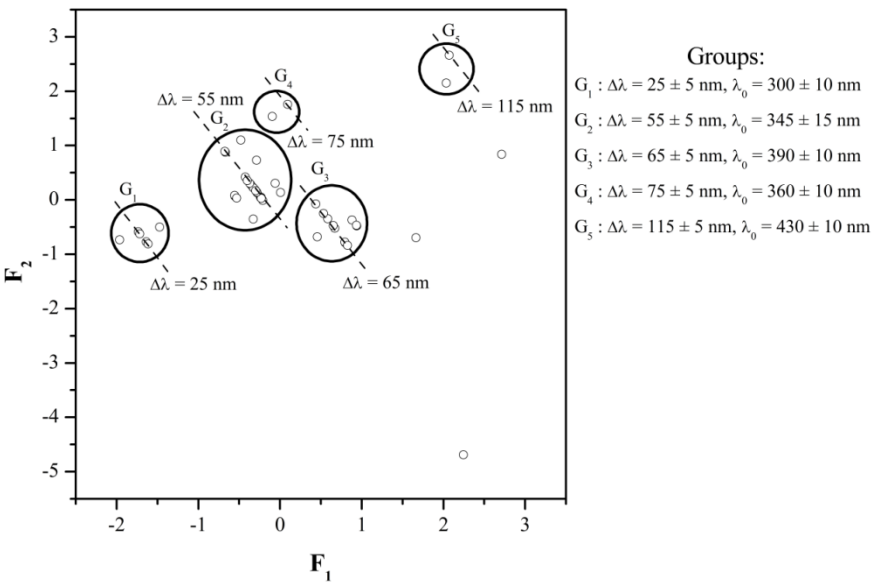

Groups:
G1 : Δλ = 25 ± 5 nm, λ0 = 300 ± 10 nm
G2 : Δλ = 55 ± 5 nm, λ0 = 345 ± 15 nm
G3 : Δλ = 65 ± 5 nm, λ0 = 390 ± 10 nm
G4 : Δλ = 75 ± 5 nm, λ0 = 360 ± 10 nm
G5 : Δλ = 115 ± 5 nm, λ0 = 430 ± 10 nm
G1
G2
G3
G4
G5
Δλ = 25 nm
Δλ = 55 nm
Δλ = 65 nm
Δλ = 75 nm
Δλ = 115 nm
F1
F2

Figure 6. Individuals (pesticides) presentation in the (F_1, F_2) plane.

CONCLUSION

It emerges from the present assay that the developed non-target spectrofluorimetric analysis of real soil or water samples must focus mainly on the existence of any fluorescence signal besides that corresponding to the natural organic matter which is bibliographically known and well characterized. Crossing field pre-survey results and profiles of the spectrometric fingerprinting database will constitute a powerful tool to follow and detect groups of emitting pesticides existing in an investigated water or soil sample. Moreover, the present approach may be used as a first screening step before the use of the sophisticated and expensive chromatographic analysis; it is hopeful and could be appropriate at least as an alert method in the case of a substantial chemical contamination of waters or soils.

A next step of this assay will be the application of Parallel Factor Analysis (PARAFAC) to decompose the TEEM complex matrices of a soil

or water sample into the primary individual fluorophore maps, and reinstate the effective number of the emitting species in the analyzed sample.

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Chapter 3

NEW CHALLENGES FOR THE MOROCCAN AGRICULTURAL SECTOR TO COPE WITH LOCAL AND GLOBAL CHANGES

Mohamed Taher Sraïri*
Hassan II Agronomy and Veterinary Medicine Institute,
Rabat, Morocco

ABSTRACT

The Moroccan agricultural sector is facing emerging challenges. First, the country is characterized by a significant water stress, as the volume of renewable water *per capita* does not exceed 750cubic meters per year. In addition, climate change scenarios predict a decrease by 10 to 15% of average rainfall and a rise of 2°C in temperatures over the next decades. As a consequence, water scarcity will be exacerbated. Second, the current national agricultural strategy, namely the 'Green Morocco Plan', aims to increase the overall production of the agricultural sector. To do so, public authorities encourage the adoption of drip irrigation coupled with financial support for drilling boreholes and for pumping

* Corresponding author address: Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco. E-mail:mt.srairi@iav.ac.ma.

equipment, e.g., to irrigate fruit trees and vegetables. As a consequence, in many areas of the country, groundwater depletion is of growing concern. Third, domestic markets have become saturated and fruit prices have plummeted, particularly citrus, hindering the original hypothesis of improved economic water productivity by horticultural crops. Moreover, the current agricultural strategy has neglected rain-fed staple crops, such as cereals and pulses, and farmers growing these crops receive limited support. Fourth, the whole economic growth of the country appears to remain highly vulnerable to the annual rainfall variability. Because of demographic growth, the country has become a net importer of food and feed, e.g., soft wheat, edible oils, dairy products (butter and cheese), maize, and soya meal, and this may be harmful for its food security. Fifth, Morocco remains a rural country, since 40% of its inhabitants are still considered as employed in the agricultural sector. This is already generating increased tensions on agricultural land. In particular, the numerous land tenure statuses often impede investments in agricultural activities that would be made on the long term. Despite these challenges, the growing domestic demand for food products constitutes a strong opportunity for improved livelihoods for the people employed in this sector. As a consequence, young farmers engage in innovative learning processes in order to achieve higher crops and livestock yields, as well as improved farms' profitability. Altogether, these elements suggest that the Moroccan agricultural sector will need to actively face new challenges, especially in relation to water management in a context of climate change, sound extension services and improved labor remuneration, as well as the satisfaction of growing food demand. These challenges may require new governance standards, which impose not only to produce higher quantities of food products but also of better quality and to do so in an environmentally sustainable way. Priority should be hence set to capacity-building of human resources and to promoting rain-fed systems that integrate crops and livestock rather than focusing only on support to heavy investments in irrigation, with limited attention to market and environmental issues.

Keywords: climate change, ecological intensification, groundwater, livestock, rain-fed crops, water

INTRODUCTION

Located in the North Western fringes of Africa, Morocco stretches from North to South on approximately 3000 kilometers of Atlantic coasts.

It is a very diverse country, encompassing several landscapes, such as high mountains (e.g., the Atlas and the Rif) and various plains and oases. This allows growing a variety of crops, like rain-fed cereals and pulses, as well as irrigated fruit trees (citrus, date palms, olives, etc.) and vegetables. These traditional products have ensured the reputation of the Moroccan gastronomy at a worldwide scale. Livestock is also an important constituent of the agricultural sector: the animal wealth consists of 3.3 million cattle, 19.7 million sheep and 6.5 million goats. It allows over a million of rural families to get steady incomes from milk and live animal sales, and it also represents a security for farmers in case of long episods of drought.

Morocco is mainly an arid to a semi-arid country as more than 93% of its 710,850 square kilometers are receiving average annual raifall levels below 400 mm. Water scarcity is already severely impacting anthropic activities, and particularly agriculture, since the latter uses more than 85% of the renewable amount of water that can be mobilized every year. The volume of renewable water *per capita* has been steadily decreasing since the 1960s as it does not exceed nowadays 750cubic meters per year; a value well below the threshold limit of water stress. Climate change also constitues a serious threat to the future of the agricultural sector in Morocco (Schilling et al., 2012), as rainfall is scheduled to decrease by 15% whereas temperatures might rise by 2°C in 2050. To overpass water constraints, Morocco has implemented since the early 1950s, under the French Protectorate, an ambitious irrigation policy mainly based on large-scale irrigation schemes and on the building of dams. This has allowed securing the yields of some strategic staple crops, like sugar beet and cane, milk and meat through the production of fodder as well as emblematic crops destined to export: citrus, vegetables, etc.

Agriculture has always been the backbone of the Moroccan economy, employing almost 40% of the active work force, even if its contribution to the gross domestic product (GDP) does not exceed 17%. The availability of workers has traditionally been considered as granted in the agricultural sector, but recent studies have revealed the limited incomes of the persons involved in such activities (Sraïri and Ghabiyel, 2017). This constitutes a

real threat to the resilience of farms in the future, as many farmers are tempted to change their jobs and join large cities. As a result, Morocco has recently become an urban country (almost 57% of its total population in 2016) wehere as it used to be a rural one (more than 70% of the population in the 1960s, according to the Moroccan official Statistical Institute). In addition, the structure of the Moroccan agricultural sector reveals a marked dichotomy between large farms and smallholder units. The latter represent the wide majority, since 82% of the farms cover less than 5 ha and produce for the local markets and farmers' own subsistence needs. By contrast, large farms, considered as modern, are primarily involved in the exports of commodities. The marked differences between large farms and smallholder units is not only related to their arable land area but can also be noted with regard to their earnings. In fact, many smallholder farms face acute constraints like ambiguous land ownership, lack of access to technical support and credit, as well as limited infrastructure. By contrast, large farms have generally registered land and can benefit from bank credits as well as government support programs, such as incentives for equipment (e.g., drip irrigation).

In 2008, the Moroccan authorities reiterated their commitment to the promotion of agriculture, through the adoption of an ambitious plan, named the Green Morocco Plan. This plan embodies public authorities' will to deal with the complex agricultural problems of the country, addressing the dichotomy of the sector, considered as divided into large intensive farms and the majority of smallholder units. The Green Morocco Plan aims to increase significantly the incomes of most of the agricultural value chains through higher productivity. It also aims to improve food security. The Plan relies on intensive investments in agriculture, particularly directed at large agribusiness farms where incentives are offered to promote practices considered as more efficient with regard to inputs' uses (land, water, capital, fertilizers, etc.), such as drip irrigation for better water productivity, tractors, machinery, etc. Public authorities have also organised favourable conditions for the development of these large farms, by means of helping them to get access to state-owned land, through state-private partnership programs (i.e., land rented for long durations at

fixed annual prices). The Green Morocco Plan has reinvigorated the nation's interest in its agriculture, but many questions remain on the appropriate measures to cope with growing climate uncertainty and to ensure the social sustainability of the agricultural sector. Public policies will have to face huge challenges in the very near future in terms of mitigating the impacts of climate change. There are striking differences between large and smallholder farms that raise the question of how the two models of farming can work together and move forward to a sustainable development of rural areas.

The present article analyses the challenges that lie ahead for the Moroccan agricultural sector, particularly with regards to water stress and the need for improved incomes for the people involved in farming activities. It also assesses current public policies and their impacts. Finally, the article proposes alternative options that might be necessary to maintain a sustainable agricultural sector, based on long-term field observations in many areas of the country.

WATER SCARCITY AND ITS CONSEQUENCES ON THE MOROCCAN AGRICULTURAL SECTOR

Water availability has certainly become the most prominent constraint for the future development of the global food sector (Mancosu et al., 2015). The same finding has been established in Morocco, and it will be exacerbated in the near future, since studies agree that climate change scenarios should induce reduced rainfall and higher temperatures by 2050 (Parry et al.2004). In fact, in numerous water basins of the country, the renewable water volumes are already totally mobilized (Agoumi and Debbarh, 2005). This is particularly the case of the semi-arid regions of the South and the East, where irrigation is mandatory to guarantee crop yields. This situation is the consequence of an increasing water demand due to irrational objectives of achieving increased cultivated areas with crops that require high volumes of water during summer, when there is no rainfall at

all and when temperatures can reach levels above 45°C. This is the case of fruit trees like apple, citrus, olives, pomegranates or date palms in the oases, as well as maize or alfalfa as fodder crops to ensure higher milk and live weight gains in cattle (Le Gal et al. 2009). In such a situation, the solutions promoted to alleviate water constraints are mainly of two kinds: an increased use of groundwater and the conversion of irrigation from farrow to drip systems. In theory, these measures seem interesting, but in reality they are far from being efficient (Batchelor et al., 2014). As a consequence, groundwater depletion has become of growing concern, and it might put at risk the sustainability of the entire irrigated sector, particularly if a sound regulation is not implemented (Kuper et al., 2016). In addition, the conversion from farrow to drip irrigation is not systematically associated with a decrease in the water volumes used, if farmers have not been correctly advised about the issue of groundwater depletion. The significant incentives provided by public authorities for the set up of drip irrigation equipment, which may reach up to 100% of total investment costs, have accelerated the rhythm of adoption of this technique, but with no insurance on its efficiency. Recent studies in the Saïs plain (North Center of Morocco, between the cities of Meknes and Fes) have shown that drip irrigation does not necessarily induce an improvement of water use efficiency (Benouniche et al., 2014). Moreover, drip irrigation exacerbates the gap between farmers with important financial means, who can invest in deeper boreholes and who will further contribute to groundwater depletion, and farmers with limited capital who may not be able to continue to access groundwater when their levels decrease (Ameur et al., 2017). Drip irrigation and the access to groundwater constitute however means to get to a special social status for farmers within their local community as they allow them to be independent from collective irrigation networks and to diversify the range of crops they are able to grow (Quarouch et al., 2014). Since the disengagement of state services from technical support programs in the 1990s, many farmers have been forced to rely on their own experience and on local networks in order to manage drip irrigation. This might delay the adoption of the learning processes needed to manage this technique (Ameur et al., 2013).

The intensification of groundwater uses and the development of drip irrigation reveal obvious constraints with regards to the sustainability of farming systems in many arid areas of Morocco. As a consequence, seawater desalination has emerged as another type of solution. However, the organizations which encourage such a technique ignore its economic effects. The cost of surface irrigation water ranges from 0.04 to 0.06 US $ per cubic meter in the vast majority of large-scale irrigation schemes and it is almost free in many traditional small-scale schemes in mountain areas, which rely on natural springs. By contrast, water from desalination plants would cost around 1 US $ per cubic meter, meaning it would be almost 20 times more expensive than the price in large-scale irrigation schemes. Consequently, such a water source would be too expensive for the vast majority of crops, as farmers cannot afford to pay these prices. Only a very limited range of high-value crops, such as tomatoes or melons destined to export, could be produced in a profitable way with such water prices, and even emblematic fruit trees like citrus and olives could not be farmed with profits with desalinated water. In addition, in recent years, farm gate fruit prices, particularly citrus destined to export, have witnessed tremendous variability. During autumn 2016 and winter 2017, due to a surge in the output of citrus fruits induced by the massive investments in the sector since 2008, with the implementation of the Green Morocco Plan, farm gate prices have fallen drastically. These prices were not higher than 0.1 US $ per kg, at a time when production costs usually exceed 0.2 US $/kg in the most performing farms. This decrease in prices was also a result of difficulties on the export markets, as the competition with other export countries (Spain, Egypt, etc.) soared. Therefore, in many citrus production areas, where farmers had significant irrigation and pests' treatments expenses due to excessive heatwaves during summer 2016, huge economic losses were recorded. In some cases, farmers finally decided not harvesting fruits, as they could not afford additional expenses related to fruit collection.

All these findings show that heavy challenges lay ahead of the Moroccan agricultural sector in the near future. Previous solutions, which mainly relied on irrigation, have come to a limit, as it is very difficult to

think of expanding the irrigated areas. Courageous decisions will have to be made. Public policies should primarily focus on adding value to rain-fed systems rather than only thinking about irrigation. This is in total agreement with a global trend that considers that, in order to address the future challenge of feeding 9 billion people by 2050, attention should focus primarily on "green water" (i.e., rainfall) rather than "blue water" (i.e., irrigation) (Falkenmark, 2007). In the Moroccan agricultural context, such a paradigm shift in the field of water uses implies a renewed interest in rain-fed systems, which have been generally neglected in the majority of policies and programs, although they still represent more than 80% of the total arable land. This paradigm shift also means specific trainings for farmers to get them to understand the sensitive topic of water productivity and its complexities, particularly in contexts where they may rely on several water sources to try to satisfy crops' and livestock needs all year long: rainfall, surface and/or groundwater irrigation, and even "virtual water" (i.e., the volumes of water needed somewhere to produce food and/or feed and which will be used elsewhere) (Allan, 1998).

In a series of studies, we analyzed the water productivity of dual purpose cattle (i.e., milk and meat produced simultaneously). These researches were undertaken because of the important and sometimes hidden water requirements to obtain animal products such as milk and meat, which are crucial ingredients for a balanced diet (Hoekstra, 2012). In the large-scale irrigation scheme of Tadla (Centre East of Morocco), in a sample of six smallholder farms, 1 kg of milk had a water footprint of 1.7 m^3. Moreover, 16.5 m^3 were needed for 1 kg of beef (Sraïri et al., 2009). A similar research protocol was used again in a sample of five smallholder units in the Saïs plain, this time with a particular attention to the source of water. The study was conducted in a region with an average annual rainfall level of 560 mm. It revealed that the water footprint of 1 kg milk was around 1.6 m^3 whereas it reached some 15.3 m^3 for one kg of beef (Sraïri et al., 2016). Interestingly, when considering the source of water in such footprints it appeared that groundwater represented only 13.1% of total water needs to produce milk and even less for beef (2.2%). These results emphasise that the contribution of livestock to groundwater depletion

remains limited in areas with sufficient rainfall, where fodder systems rely mainly on autumn and winter crops, such as barley, berseem (clover) and oats, cultivated during the rainy season, whereas the contribution of summer irrigated fodder crops such as maize and alfalfa is limited. The results of this study are in line with Sultana et al.'s (2014) global evaluation of water use in cattle farms, which concluded that the key for sustainable dairy cattle systems should be a decrease in the use of irrigation, particularly from groundwater. Public authorities in Morocco should carefully analyze such a recommendation, as they need to implement more cautious approaches to the development of dairy systems in arid and even desert areas. They should also adopt regulatory measures to avoid the collapse of such activities in the near future that could be caused by groundwater depletion.

These studies show that more cautious approaches should also be used to analyse the profitability of crops, as it should integrate the origin of the water used. In the Saïs plain, there have been recently significant investments in fruit trees and vegetables (particularly onions and potatoes), which were encouraged by the development of drip irrigation equipment. These crops have been presented as more profitable than 'traditional' farming systems, which are based on livestock and cereals and pulses. However, no serious analysis has been devoted until now to the contribution of such emerging cropping patterns to the phenomenon of groundwater depletion. This is a high priority item because these emerging cropping patterns almost entirely depend on irrigation as they are cultivated in summer, in comparison to more traditional farming activities (cereals, pulses, livestock, etc.) which rely almost exclusively on rainfall. Moreover, the volatility of fruits and vegetables prices adds complexity to the analysis of water productivity in its economic dimension, as sometimes farm gate prices may decrease to levels which do not guarantee the profitability of irrigated crops, as it has been demonstrated for onions in the Saïs plain (Lejars and Courilleau, 2015).

The paradigm shift from irrigation to rain-fed farming should also be implemented in public strategies dealing with the agricultural sector. This has to to be integrated in the assessment of the current Green Morocco

Plan, as this Plan brings until now a very limited specific support measures to the rain-fed systems. As a consequence, a renewed interest in research and technology transfer to farms has to be promoted in order to decrease the significant gap between actual and potential yields in cereal and pulses production. Cereal crops still represent approximately 55% of total land cultivated with annual crops. They need specific research programs to find solutions, in cooperation with farmers, to some of the acute constraints facing rain-fed systems: rainfall interannual variability, drought, soil degradation, selected seeds, appropriate use of fertilizers, etc.

WORK IN AGRICULTURE AND ITS REMUNERATION

One of the direct consequences of the semi-arid to arid climates characterizing the vast majority of the Moroccan arable area is the climate impacts on crop yields. This is particularly obvious in areas with no possibilities of irrigation at all, and where the most commonly cultivated species remain cereals. In such systems, the crop/livestock association is highly relevant because ruminants graze crop residues, particularly cereal straws which are vital feed resources in case of long drought episodes (Magnan et al., 2012). Livestock constitutes an asset in most of the farms as it is also a means of diversifying the sources of income. They also provide family members with milk and live animals which may be consumed or sold. In such systems, work is traditionally assumed by family members. Very few studies have paid attention to the work load and its remuneration in such family-based smallholder farms, although the work constraint is being considered as a "hot topic" in many countries, particularly in systems involving livestock (Dedieu and Servière, 2012). In fact, work load in crop/livestock farms represents a heavy burden which has to be correctly remunerated and shared between farmers, the members of their families and hired workers. The study of work organization and payment in mixed crop-livestock farming systems is hence emerging as a priority research topic in many areas worldwide, as it may help understanding the performances of farms and enhancing their sustainability

(Lemaire et al.,2014). Generally, work productivity in farming activities remains limited, as too many workers are trying to get paid from agriculture which is not sufficiently productive because of a lack of inputs and arable land (Sraïri, 2005). Two separate investigations were carried out in order to characterize work constraints in details in diverse farms having limitations with regards to land, water and capital in Morocco. Research protocols were based on the use of the "Work Balance" method (Dedieu et al., 1999). The method was used in 44 farms, mainly smallholder units but also larger farms, located in two regions: the Saïs plain (mainly rain-fed production with possibilities of complementary irrigation from groundwater) and the Gharb large-scale irrigation scheme (North of Morocco) (Figure 1).

First, data were collected in 30 family farms of different sizes and differing use of capital in the Saïs plain. Farms of very small scale (less than 1 ha) specialize in cattle rearing, with an important share of endogenous work being dedicated to this activity, particularly weed cutting in neighbouring large farms to feed their herd, grazing animals, etc. (Table 1). By contrast, farms with more land and capital tend to diversify their activities, mainly towards cash crops (vegetables and fruit trees), resulting in an increased use of hired workers. These farms still maintain however some livestock activity, because of the regular incomes that can be obtained (Sraïri et al., 2013). Second, the "Work Balance" method was implemented in 14 diversified family farms in the Gharb large-scale irrigation scheme. Work times in each agricultural activity (livestock and crops) were quantified, distinguishing the contributions of family members and those of the farm workers.

The results revealed a very limited work remuneration from livestock as it does not exceed an average income of 2.5 US $ per day; a value far below the officially guaranteed salary in the agricultural sector. By contrast, the gross income of work related to crop production is much higher, with a mean value of 110 US $ per day. This is due to high-value cash crops such as sugar beet and vegetables (Sraïri and Ghabiyel, 2017). Such high-value cash crops face however highly volatile farm gate prices, which imply economic risks. On the contrary, the prices of cereals, pulses

and milk do not fluctuate much. Moreover, the production of cereals and pulses is highly mechanized and therefore their work needs are limited.

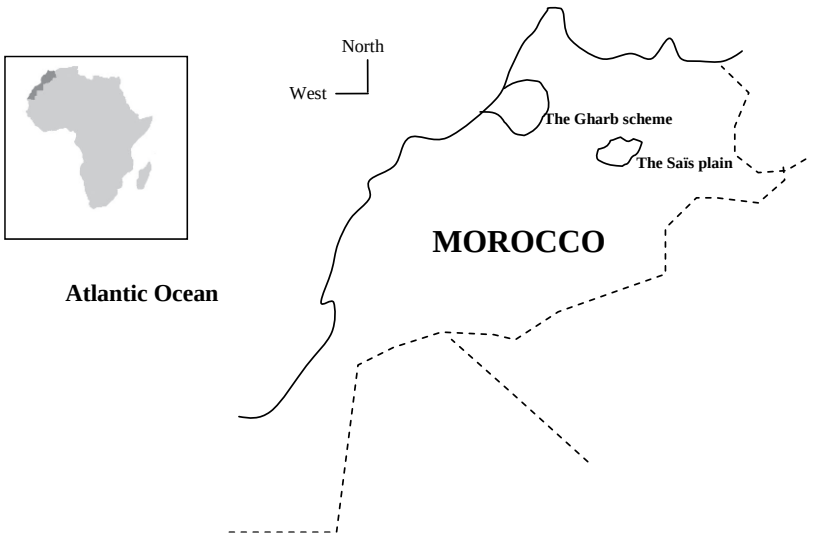


Figure 1. Location of the study regions: the Gharb irrigation scheme and the Saïs plain.

Altogether, these two studies confirm the crucial participation of smallholder farms in the supply of raw milk and beef, given they have almost no options in investing in cash crops. However, the limited gross margins obtained from cattle rearing imply that it could have limited attractiveness for the young generations: in fact, the number of farmers already decreases, as many people from rural areas migrate to large cities for work.

Table 1. Livestock routine work load in a study of 30 crop/livestock sample farms

	Mean ± standard deviation	Min. - Max.
Livestock routine work load (hours/year)		
Total	1912 ± 706	957 - 3643
Per livestock unit	419 ± 202	120 - 851
Per ton of milk delivered	272 ± 203	45 - 851

Based on Sraïri et al. (2013).

In larger farms, livestock is kept as a mean of diversifying sources of income. Farmers put forward its limited gross margins and its relatively high needs in terms of work. Finally, in a context of growing tensions in terms of workers' availability, the issue of work has to be fully considered in the Moroccan agricultural sector, whether it is assumed by family members or it comes from hired workers. This may add new constraints to the achievement of the ambitious official objectives in terms of the increase of staple food and animal production in the coming years.

FOOD PRICES VOLATILITY AND THEIR EFFECTS ON FOOD SECURITY

The global agricultural sector will have to face acute challenges to ensure the supply of food to a fast growing population. In order to avoid social unrest and troubles related to food crisis (Bellemare, 2015), urgent measures have to be taken to promote sustainable agricultural production. In Morocco, the same finding is valid, as the country used to be a net exporter of food, and this situation has prevailed until the late 1960s. However, with a vigorous demographic growth (from 11.6 to 34.8 million from the early 1960s to 2017), it has rapidly become a net importer of food. In addition, the country has witnessed a marked process of urbanization, as almost 60% of its population have nowadays become urban dwellers, implying that food consumption habits have changed and that new emerging metabolic diseases increase, such as obesity, cardiovascular diseases, cancer, diabetes, etc. (Mokhtar et al., 2001). As a consequence, food demand has increased significantly, and despite ambitious agricultural policies, Morocco has become an importer of staple food. The value of current food imports has reached nowadays almost 4.5 billion US $. These imports also encompass feed ingredients for livestock and poultry (maize grain, bran, beet pulp, barley grain, etc.) as it is shown in Table 2. The food balance of payments has become in deficit and only

sea products (fish, shellfish, etc.) allow Morocco to have a relatively balanced trade deficit with regard to food products.

Another characteristic of Moroccan feed and food imports is their marked variability in relationship to climate hazards. In case of acute drought, the yields of the main crops fall and that impacts the overall economic growth of the country, as it was observed during the acute drought of winter 2016: less than 1.5% of GDP growth that year in comparison to 4.8% in 2015. Consequently public authorities are forced to massively import grains in order to feed the population and even livestock. This is well illustrated by the variation in the yield of the three main cereals (soft wheat, hard wheat and barley) over the last 35 years and its consequences on imports (Figure 2). Grain imports also show a growing trend in substitution of barley (particularly suited to Moroccan climate thanks to its adaptation to drought) by soft wheat in consumption habits. In fact, even in favourable years, the amounts of imports remain high, since the quality of domestic yields (dominated by barley) is generally low and local grain mills prefer using imported grains (i.e, soft wheat).

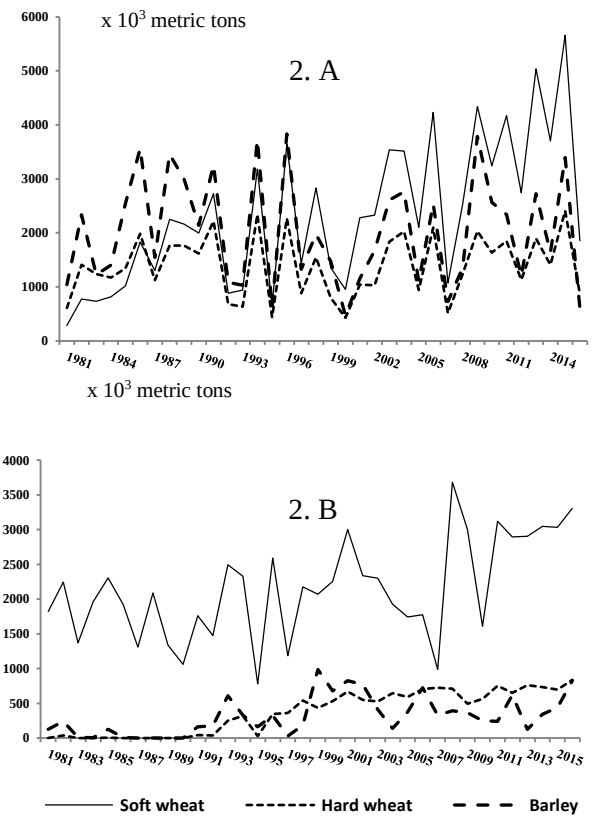
Table 2. Main food and feed imports in Morocco (2016)

	Imports (metric tons)	Imports per capita (kg)	Imports (x 10^6 US $)
Wheat grain	4,608,000	139	834.5
Maize grain	1,780,000	54	484.4
Sugar	920,630	28	439.7
Soya meal	469,000	14	266.0
Soya oil	456,550	13	379.8
Beet pulp	378,150	11	110.7
Butter	32,390	1	99.1
Cheese	13,840	0.4	68.2
Wheat bran	215,000	6	52.4
Barley grain	180,000	5	51.2
Soy grain	63,000	2	38.9

Source: Office of Currency Change (2017).

As a consequence of these recent changes, Morocco has become highly vulnerable to the fluctuations of the prices of main cereals in global markets, which directly affect its expenses. Since public authorities are still

heavily subsidizing soft wheat (which remains the major ingredient of bread and a vital component of the diet), the cost of subsidies will soar whenever wheat prices on global markets increase. That was noticed during the global food crisis of 2008 and at that time, in order to avoid social unrest and even riots (Berazneva and Lee, 2013), public authorities officially announced that there would be no increase in bread price. However, this decision came at high cost for the national budget.



Source: ONICL (National Interprofessional Office of Cereals and Pulses), 2017

Figure 2. Evolution of the domestic production (2. A) and imports (2. B) for the three main cereal grains: soft wheat, hard wheat and barley.

THE NEED FOR A DIVERSIFIED AGRICULTURE WITH MORE ENVIRONMENTALLY FRIENDLY PRACTICES AND ENHANCED CAPACITY-BUILDING PROGRAMS

The differentiation between irrigated areas and rain-fed ones has progressively created significant discrimination within the Moroccan agricultural system. The latter almost do not benefit from public aids and research efforts, whereas most of the public and private investments are made in irrigated areas. These two areas are not completely disconnected: the rapid expansion of private irrigation based on wells and boreholes, has allowed many farms to manage both irrigated and rain-fed cultivated plots. The complementarity between the two areas is actually the key in supporting the resilience of many farms. First, productions from rain-fed cereals and pulses are used to supply food to family members and surpluses can be sold. Second, these crops residues, like straws, stubble, bran and also the quantities eliminated during sorting, are used to to feed the herd which constitutes a security for the family in case of disaster (e.g., drought or floods) or unexpected expenses. Livestock has also a crucial role in supplying manure, which constitutes an efficient way for restoring soil fertility with organic matter and nutrients, in a country where soil degradation has become a critical issue (Bessam and Mrabet, 2003). Finally, the production of irrigated crops is less risky and can provide more secure incomes, whenever farm gate prices are favourable.

Another differentiation has taken place between a minority of very large farms, supposed to be more productive and modern, and thousands of smallholder farms considered as archaic. Current public policies in the agricultural sector embodied through the Green Morocco Plan have emphasized this dichotomy and many observers believe that such Plan was even made without consulting researchers' recommendations in alleviating these differences (Akesbi, 2015). The Green Morocco Plan mainly gives priority to large intensive specialized farms (particularly in fruit trees and vegetables), encouraging cash crops exports rather than food for the Moroccan population. In addition, the Plan is based on simple typologies

of farm according to their arable area. In doing so, it does not allow for an integration of farming activities and the promotion of synergies within rural areas (Faysse, 2015). "Modern" practices adopted in the large specialized farms, such as intensive cropping under irrigation and heavy tillage might not be environmentally friendly, as they lead to a loss of soil organic matter. There are even concerns that public authorities, urged by their main international donors (namely the World Bank and the International Monetary Fund) are pushing towards a model of intensive agriculture dependent on global markets and liberalization.

However, smallholder farms remain key players in the supply of animal products (milk and meat) and staple food (cereals, pulses, vegetables, etc.). Therefore it is important to ensure the resilience of these smallholder units which have diversified activities. Crop/livestock association is a key component of sustainable agricultural systems, as it allows crop rotation and a decrease in pesticides uses (Lechenet et al., 2017). This type of farming is actually more resilient than specialized farms with regards to economic and climate hazards (Ryschawy et al., 2014). Diversifying agricultural practices and types of farms appears to be a complicated task as it requires an improvement of the links between these farms and the markets as well as a specific support to the development of independent producer organizations, such as farmers' cooperatives. However, agricultural cooperatives still face many constraints, particularly when it comes to critical management issues such as payment systems and quality improvement measures (Ourabah Haddad et al., 2017). Nevertheless, supporting the emergence of well-managed independent farmers' cooperatives can strengthen the resilience of smallholders and enable them to contribute meaningfully to a sustainable food supply for Morocco. Capacity-building programs are urgently needed to achieve such a goal. The potential benefits of such type of training were demonstrated in a small sample of cattle farms (Sraïri et al., 2011). Priority should hence be given to capacity-building programs rather than focusing only on heavy financial incentives on machinery and equipment.

CONCLUSION

Morocco faces many problems related to water scarcity and climate change will further increase these problems. Significant changes in agricultural policies are required in order to find solutions to the growing water demand. To avoid a mining exploitation of water resources which will further hinder the sustainability of farming systems in many areas of the country, public policies will need to implement genuine regulation policies. Current policies have actually exacerbated the gap between rich and poor farmers, and between a minority of large farms and the vast majority of smallholder units, which are still considered by many as inefficient. The structural characteristics of the Moroccan agricultural sector make it necessary to imagine new approaches for improving the performances of this sector. Since smallholders comprise a major part of the sector, there is a real opportunity to improve people's livelihoods and food security, as well as to prevent further environmental degradation.

Government policies need to recognise the importance of an integrated and diversified agriculture. Policy makers should understand that rural and agricultural development implies dealing with complex affairs that cannot be solved just by simplistic measures, such as heavy investments in drip irrigation and groundwater exploitation as well as the promotion of cash crops for export. Agricultural policies have to take into account the complementarities and interactions between rain-fed and irrigated systems, between crops and livestock, as well as between on-farm and off-farm labor. To do so, a paradigm shift has to take place. This entails a renewed interest to rain-fed systems and to a better use of rainfall, particularly in the production of cereals, pulses, fodder and crop/livestock association. This shift in paradigm also requires acknowledging the key role of smallholder farmers in Moroccan food systems. These hard-working people hold the key to Morocco's future. Specific capacity-building programs can improve their skills and technical know-how about sound agricultural practices, in order to increase their incomes and avoid rural exodus.

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BIOGRAPHICAL SKETCH

Mohamed Taher Sraïri

Affiliation: Hassan II Agronomy and Veterinary Medicine Institute, Rabat, MOROCCO

Education: Master in Agronomy, Hassan II Agronomy and Veterinary Medicine Institute, Rabat, MOROCCO - Ph D, Gembloux Agricultural University, BELGIUM

Business Address: Hassan II Agronomy and Veterinary Medicine Institute, 1, Allal Fassi Road, P.O. Box 6202, Madinate Al Irfane, 10101, Rabat, MOROCCO

Research and Professional Experience:

Assistant professor in Animal Science at Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco, from 1994 to 2007.

Associate professor in Dairy Science at Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco, from 2007 to 2012.

Senior Dairy Science lecturer at Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco, since 2013.

Main fields of competences:

1. Characterization of milk production systems within smallholder farms;
2. Farming practices and their consequences on milk chemical and hygienic quality;
3. Water productivity in dual purpose (milk and live weight gain) cattle rearing;
4. Management of the work constraints within crop/livestock systems;
5. Challenges in milk collection dairy cooperatives with numerous daily supplies

Professional Appointments:

Responsible of several courses and trainings at Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco:

1. Introduction to Animal Production;
2. Dairy Production;
3. Writing a bibliography and a scientific article;
4. Methods of studying a farming unit.

I have also been the head of the Department of Animal Production and Biotechnology from 2010 to 2015, where I have managed several curricula as well as international research programs.

Publications from the last 3 Years:

1. *Sraïri, M.T.* & Ghabiyel, Y. *2017*. Coping with the work constraints in crop-livestock farming systems. *Annals of Agricultural Science*. 62, 23-32.
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Chapter 4

GREEN ECONOMY IN MOROCCO: AN ANALYSIS OF THE REFORMS AND LIMITS

Fatima Arib*
Research Laboratory "Innovation,
Responsibilities and Sustainable Development INREDD"
Faculty of Law, Cadi Ayyad University, Marrakech, Morocco

ABSTRACT

Many efforts have been made in recent decades in Morocco in the priority areas of sustainable development and the environment to promote a green and inclusive economy while taking into account the threefold aim of respecting the environment, fighting against poverty and sustaining the economic activity. However, the country remains compelled for a better mobilization against the sources of environmental degradation. Several kinds of limitations hinder this transition today and a number of challenges still need to be addressed to begin the transition to the green economy and, more broadly, to sustainable development.

Keywords: Morocco, green economy, reforms, development

* Professor of sustainable development economics. Corresponding Author Email: f.arib@uca.ma.

ACRONYMS

ABH	Agence du Bassin Hydraulique /Hydraulic Basin Agency
ADEREE	Agence de Développement des Energies Renouvelables et de l'Efficacité Energétique /Agency for the Development of Renewable Energies and Energy Efficiency
CEA	Commission Economique pour l'Afrique /Economic Commission for Africa
CESE	Conseil Economique, Social et Environnemental / Economic, Social and Environmental Council
Dhs	Dirhams
FDA	Fonds de Développement Agricole /Agricultural Development Fund
FDI	Fonds de Développement Industriel /Industrial Development Fund
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit / German development agency
IRESEN	Institut de Recherche en Energie Solaire et Energies Nouvelles /Institute for Research in Solar Energy and news Energies
MASEN	Morocco Agency for Solar Energy
MEMEE	Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement /Ministry of Energy, Mines, Water and Environment
OCP	Office Chérifien des Phospahates / Cherifian Office of Phosphates
OIT	Organisation Internationale du Travail/International Labor Organization
OMD	Objectifs du Millénaire pour le Développement / Millenium Objectives for Development
OMI	Observatoire Marocain de l'Industrie / Moroccan Observatory of Industry
ONE	Office Nationale de l'Electricité/National Office of Electricity

ONEM	Observatoire National de l'Environnement du Maroc / National Observatory of the Environment of Morocco
ONHYM	Office National des Hydrocarbures et des Mines / National Office of Hydrocarbons and Mines
PIVM	Plan d'Investissement Vert du Maroc /Morocco Green Investment Plan
PMV	Plan Maroc Vert / Green Morocco
PNUE	Programme des Nations Unies pour l'Environnement/ United Nations Environment Program (UNEP)
SIE	Société d'investissement Energétique/ Energy Investment Company

1. INTRODUCTION

The green economy is a means to achieve the objectives of sustainable development that requires a whole process of structural adjustment of economic activities that respect the environment. It is often presented as an alternative that potentially brings new opportunities, fosters business competitiveness, enhances skills, develops clean technologies and attracts new investment needed to reduce poverty and unemployment, which are two of the major challenges in Morocco.

Today, the green economy is a strategic axis for the national policy of sustainable development. This is evidenced by the institutional, regulatory and financial reforms, incentives and efforts to mobilize development actors around new partnerships with the aim of operationalizing the National Charter for Environment and Sustainable Development and promoting new strategic sectors in the important areas of renewable energies, energy efficiency, water and waste treatment. Despite these efforts, the actors are always called upon for a better mobilization against the environmental degradation and initiatives that have been undertaken in Morocco in regards to sustainable development and environmental protection. It then analyzes a set of constraints and limits that the various reforms encounter.

1.1. Programs, Reforms and Initiatives

In addition to socio-economic development plans, Morocco has launched several structuring programs in the environmental fields in recent years: water, air, coastal areas, land, energy, energy efficiency and waste.

Table 1. Major programs for environmental sector

Sectors	Major programs
Water	• National *Irrigation Water Saving Program* • *National liquid* sanitation and *wastewater treatment program*
Air	• National Anti- Air Pollution Program (Creation of a network of 21 stations for air quality control) • New logistical strategy
Coastline	• Coastal Pollution Control Program
Soil	• *National Action* Plan for the Fight *against Desertification*
Renewable Energies /Energy efficieny	• Solar plan[1], integrated wind plan • National Energy Strategy[2] NES • Energy Efficiency in buildings, industry, agriculture, transport, public lighting • Differentiated tariffs • National program for low-consumption lamps • Solar water heating program • Application of GMT + 1[3] • Regionalization program "Jiha Tinou"[4] • *Development Program* of the *Moroccan market for solar water heaters*
Waste	• Industrial Pollution Prevention National Program • National Renewable Energy and Energy Efficiency Program • National Program for the Collection and Disposal of Plastic Bags • National Program for household waste Management • National Program for Special Waste Disposal • Landfill treatment plan

[1] Morocco benefits from its abundant solar resources (a potential of 2,600 kWh/m²/year) and from its strategic position at the heart of an energy hub (Connection to the Spanish network through two electric lines 400kV/700 MW).

[2] The NES aims to reduce the pressure of energy on the national economy with sectoral objectives (Building, transport, industry, agriculture and fisheries.).

[3] During the periods from 28 April 2013 to 07 July 2013, and from 10 August to 28 September 2013, the energy gain is approximately 60 GWh.

[4] This program falls within the framework of advanced regionalization. It aims to optimize the capacity of local actors to contribute in different ways to Morocco's energy objectives by 2020.

These programs have been strengthened by more flexible measures to encourage economic operators, particularly industrial ones, to mitigate the impact of their activities on the environment and to create new green sectors. Energy, energy efficiency and household waste have been the subject of several studies (CESE, 2012)[5] in order to show the great opportunities in terms of job creation.

Table 2. Major green economy programs

Program	Main Objectives	Budget	Potential Employment
Integrated solar and wind plan	– To save 2.5 million TOE – To avoid the emission of 9.5 million tones of CO2 per year	100 billion DH	23 000 jobs (2020)
The *National Liquid Sanitation Plan*	– Increase the rate of sewer connection to 80% in urban areas by 2020, and 100% by 2030. – Increase the rate of urban wastewater treatment to 60% by 202a	43 million DH	10 000 directs jobs (2020)
The *National Program* of *Household Waste*	– Improving the collection of household waste (85% in 2016 and 90% in 2020.)	37 billion DH	11 000 directs jobs (2020)
	– Rehabilitation of landfills and creation of new landfills Promotion of new sectors: sorting, recycling		
The National Energy Efficiency Strategy	– Reduce national energy consumption by 25% by 2030. Sectors: Buildings (-20%), industry (-2.5), transport -35%), agriculture and fisheries (0.2%) – Reduce the energy bill by 12% in 2020 and by 15% by 2030 (30% for the construction industry)	21 billion DH	40 000 directs jobs (2030)

[5] CESE (2012), Economie verte: opportunités de creation de richesses et d'emplois, Rabat.

1.2. Sectors of Water and Energy

Other structuring projects are planned in the water sector by 2030: the transport of 800 million m3 from the North to the South of the country (24 billion Dhs), the construction of 60 dams to mobilize 9 billion m3, expansion of liquid sanitation and sewage treatment programs, subsidies to optimized and environmentally-friendly irrigation systems as well as awareness-raising actions for rational water management in industry and the residential sector.

The national strategy for sustainable development includes measures for the development of agricultural water: the price of this resource remains derisory (3 Dhs per cubic meter but for example, 12 Dhs in Spain), the taxation of large farms which started in 2014 and the VAT reform which aims to broaden the tax base and establish a dual-rate system. The launching of the Morocco Green Plan in 2008 has allowed the replacement of classical gravity irrigation with drip irrigation.[6] The development of a green economy will enable Morocco to save 2.5 billion m3 of water.

Energy is one of the strategic stakes in Morocco. The country has identified a set of measures and has defined the programs and action plans to reduce its dependence on fossil fuels. Renewable energy, which is a major component of the new energy strategy, is expected to account for 42% of the installed capacity, developing 2,000 MW of solar, wind and water power each and nearly 20% of national electricity generation is expected to come from renewable energy sources ensuring the supply of energy while reducing the dependence on energy imports. Morocco can become a competitive supplier of particularly solar electricity, wind power[7] and biofuels. Beyond reducing the imported energy bill, Morocco should export 20% of its green energy by 2020-2025.

[6] Gravity irrigation is the dominant form of irrigation with more than 80% of irrigated land in 2008, compared to drip irrigation, which covers only a small area.

[7] Morocco has huge potential in wind power, relying on wind resources in several regions, particularly along its coasts, but which is limited mainly by the capacity to integrate into the electricity grid at least in the medium term, by 2020.

The National Energy Efficiency Strategy aims to reduce the energy bills by 15% by 2030. The efforts are focused more on the industrial, agricultural and construction sectors which have a potential to save energy and reduce greenhouse gas emissions. Signing the Energy Charter Declaration[8] could give Morocco a better visibility of the sector and make it more attractive to foreign investors and the energy industry. Eliminating subsidies for fossil energy products could also foster the development of alternative sources of green energy, and help firms turn to cheaper, more efficient, cleaner and sustainable production systems. Several attractive offers to investors in the renewable energy sector have been put in place such as the contribution of the Energy Development Fund to the financing of investment projects, subsidies for goods and equipment, support for training and R&D, creation of zones specifically dedicated to the sector (Cleantech of Oujda).

In addition to the new logistical strategy which aims at reducing 35% of the CO_2 emissions linked to freight transport, Morocco has developed around 60 clean development mechanism (CDM)[9] projects in the sectors of energy, industry, transport, sanitation, agriculture and reforestation to reduce greenhouse gases. These include energy saving projects or the use of alternative energy sources, the use of natural gas in industry, reforestation and the production of biogas from waste. These projects are expected to significantly reduce CO_2 emissions by 2020.

The adaptation of the methodology "Environmental Approach of Urbanism" aims to facilitate the consideration of environment and energy in development and planning projects and the operational alignment of environmental objectives. The specifications of the Ministry of Housing also obliges any real estate developer involved in the production of low-cost housing (this type of housing represents 60% of Morocco's housing supply) to integrate pipes that is suitable for solar heating.

[8] It is an international legal instrument that aims at improving the legal framework for energy projects and investments.

[9] Most of these projects are carried out by MASEN, the Moroccan Agency for Solar Energy, and Nareva, SNI's renewable energy subsidiary.

1.3. Other Programs and Initiatives

Morocco has implemented a program for the management and disposal of PCBs[10] with financial support from the Global Environment Facility (GEF) in collaboration with UNIDO and UNDP. The program aims to strengthen the regulatory framework and national capacities for the safe management and disposal of PCBs and the establishment of a local infrastructure for the dismantling of equipment and the decontamination of oils and materials to be reused. An initial collection and disposal campaign was carried out in 2012. It eliminated 996 units with a total weight of approximately 594 tones at an approved processing center. It pointed out that 19 national companies benefited from the first operation and obtained certificates of destruction attesting to the environmentally sound disposal of their PCB equipment. A second campaign was launched in 2014.

Actions have also been taken by the public authorities in the handicraft sector in partnership with the craftsmen such as the establishment of collective stations for the recovery and recycling of chromium from tanneries in Fez, awareness-raising and demonstration campaigns about methods of reducing pollution caused by chromium in tanneries, relocation of the workshops in medinas outside the cities, acquisition of furnaces with low environmental impact (Marrakech, Salé, Fez), with the aim of gradually eliminating traditional furnaces. Support for associations, access to information, impact studies and public inquiries are examples of actions taken to promote the green economy.

Morocco has also established several cooperation mechanisms (subsidies, agreements, public-private partnership, South-South cooperation) to support measures to protect resources and environments. That is how other projects have been developed in recent years: financing industrial decontamination projects by water basin agencies,

[10] Polychlorinated biphenyls, commonly referred to as "PCBs," are hazardous chemicals formerly used as a dielectric fluid in electrical appliances (transformers, capacitors, regulators, etc.) belonging to the family of persistent organic pollutants (POPs).

environmentally friendly urban transport[11] projects such as trams in Rabat and Casablanca, Energy efficiency Pact which helps saving energy through the use of low-consumption lamps with a pricing system.

The projects of Green Cities that have been developed mainly by the three operators: Al Omrane, the CDG (Caisse de Dépôt et de Gestion.) and the Cherifian Office of Phosphates OCP (Green City in Benguerir, new city of Lakhyayta, as pilot cities) with the implementation of solutions to minimize CO2 emissions, the creation of 3 plants for recycling used tires, oils and batteries, valorization of household waste, development of waste recovery in cement works, the valorization of bituminous products used in pavement resurfacing, the green mosques project[12] which aims to reduce the energy consumption of mosques by 30 to 40%, the project "Sustainable Hammams in Morocco" launched by the association" Energie, Solidarité, Environnement (EnSEn)," to reduce the bill of Hammams and their GHG emissions. These are some of the many examples of initiatives taken by different actors.

The new national sustainable development strategy aims to increase the accountability of the various ministerial departments by forcing them to integrate a sustainability component into all public policies. Government projects will need to focus on water and energy economics to rationalize consumption and reduce pressure on scarce resources and adaptation to climate change. Indeed, Morocco is the second African country, at this level, after Gabon, to contribute to the fight against climate change in the perspective of the Paris conference (COP 21)[13] in December 2015, where a global climate agreement is expected to be concluded. Morocco has committed itself since June 2015 to reducing its projected greenhouse gas

[11] The bus lane infrastructure (subway, tramway or bus rapid transit - 50% of the needs) in the 10 main Moroccan cities requires around € 2.3 billion (i.e. the construction of nearly 630 km of main axes over the next 10 years).

[12] As part of the national energy strategy, MEMEE, ADEREE, SIE and the Ministry of Habous and Islamic Affairs have signed a convention to improve the energy efficiency of mosques of various sizes "Green Mosques". The project starts with 1000 mosques and will spread out to 15000. Energy audits and trainings are scheduled within this framework.

[13] Morocco will host the 22nd Conference of the Parties of the United Nations Framework Convention on Climate Change in 2016 which will launch discussions on how to operationalize the new International Climate Agreement adopted at the Paris conference in 2015.

emissions by at least 13% by 2030 compared to 2010. It will allocate 10 billion dollars to this climate goal.

Morocco has also undertaken to accelerate the pace of operationalization of certain structural reforms, particularly those related to justice, regionalization, the organic finance law, compensation, the pension system as well as taxation. Efforts have also been made to promote education for sustainable development and the environment. These themes are increasingly integrated into school curricula. Universities now offer graduate degrees on environment and sustainable development and support research projects on environmental themes. Some publications and websites also help to make known and put into perspective the responsible practices of companies.

Several measures have been taken to support and promote SMEs development: Flexible legal, administrative and tax framework, reform of the financial sector, National Charter for SMEs, CNEA,[14] etc.). The National Agency for the Promotion of SMEs was set up to support these measures. It manages an extensive technical assistance program which includes aid for energy and environmental services. Imtiaz[15] and Moussanada[16] are the major SMEs support program implemented by the ANPME. These programs aim to accompany them in the realization of their development projects and to strengthen their competitiveness. The agency also offers several products such as the YAKADA intelligence report published by the intelligence cell to meet the needs of SMEs in terms of economic intelligence and strategic intelligence (with its various commercial, competitive, technological and environmental components).

[14] The National Business Environment Committee (CNEA), in partnership with the private sector, provides a platform for coordination and monitoring of horizontal reforms to improve the business environment.

[15] It is designed for SMEs with high growth potential and allows companies with ambitious development projects to benefit from a grant in the form of a premium granted by ANPME of up to 20% of the total amount of the investment within the limit of 5 million Dhs.

[16] It is intended for enterprises in the modernization phase. It aims to improve their productivity and strengthen their competitiveness. The offer is made up of several service packs covering all the needs of companies. This program covers between 60% and 80% of the cost of providing services that can be up to 1 million Dhs in particular in the context of progress plans.

1.4. Role of International Cooperation

Morocco's cooperation with its partners on the environment has played an important role in the implementation of a national environmental policy and the promotion of sustainable development. The financial and technical support provided by partners and bilateral donors aims at strengthening institutional, legal, financial and human capacities or carrying out actions that are often demonstrative.

These various programs, measures and initiatives should encourage the predominantly industrial enterprises to minimize the impact of their activities on the environment. On the other hand, the implementation of these programs will depend on incentives for private investors to finance projects and the operationalization of the many funds dedicated to them in partnership with several international organizations. The overall impact of all these efforts will also depend on their ability to transform the behavior of economic actors and to impose the adoption of new responsible modes.

2. CONSTRAINTS AND LIMITATIONS

There are a number of opportunities for development actors to open up new perspectives on new market segments,[17] strengthen the country's competitiveness and contribute to reducing environmental externalities. Efforts in the area of governance and environmental policy have helped to reduce the rate of degradation of some natural resources, encourage companies to take action to reduce pollution, stabilize carbon emissions to less than 2 tons per capita.[18] The latest Climate Change Performance Index ranked Morocco 9th in the world in 2104, which reflects the huge efforts made by Morocco to combat global warming.

[17] Several experiments have shown how, for example, waste is made of electricity, fuels or composts, or how wastewater from a treatment plant becomes a deposit of organic matter that can be used for the production of bioplastics.

[18] 1.2 tons of CO_2 per inhabitant in 2000 and an average of 1.8 between 2010 and 2014.

Yet, the transition to a green economy faces constraints that need to be overcome and the country still needs several forms of support, especially financial and technological support, to achieve the ambitious objectives of these programs. With regard to the costs of environmental degradation, the total investment budget of the Department of the Environment, (equivalent to about 2% of total state investment expenditure in 2012) seems insufficient to overcome the various identified challenges.

2.1. Various Limits

The development of the green economy is hindered by the lack of decrees on the application of certain laws, the inapplicability of existing environmental protection regulations, the inadequacy of the current incentive framework and the lack of a coherent legislative framework on environmental monitoring and assessment. Eco-taxation is not developed yet, penalties and fines for non-compliance with environmental standards are generally not enforced and so are emission charges. Indeed, a large-scale regulatory culture mainly based on negotiation remains predominant and consensus-building and voluntary approaches are strongly encouraged. Likewise, environmental self-monitoring is often voluntary, compliance monitoring is very limited and resources devoted to compliance are very modest. In addition, the monitoring system is not effective although measures have already been taken in this regard and the number of inspections following the environmental impact assessment procedure or following projects that have benefited from industrial remediation financing remains very limited.

The socio-economic context, coupled with environmental emergencies, requires substantial reinforcement of these actions at different sectoral and territorial levels. Even though Morocco has taken steps towards intersectoral coordination and comprehensive strategic planning, efforts are still needed to improve sectoral integration and to develop a structured strategy for the green economy. Despite recent efforts to prepare for advanced regionalization, the programs presented above are not

sufficiently integrated at the regional and local levels and suffer from the weak mobilization of private funding and measures and means for laws monitoring and enforcement.[19] Municipalities are mostly unable to manage their environmental problems, including liquid and solid waste, and mobilize the necessary funds and land. The lack of programs for industrial waste and the delay in developing provincial waste management plans will further complicate the implementation of this strategy.

Other constraints are also raised by several studies carried out by the various national organisms: ministries, agencies.[20] These include the lack of national expertise and expertise in wind and solar technologies, the lack of mechanisms for industrial integration in invitations to tender in renewable energy projects, and the limited integration of local SMEs in major national projects. It indeed seems that the nature and size of renewable energy programs today in Morocco make investments that favor large companies to the detriment of SMEs and very small enterprises VSEs.

The development of the green labor market is hampered by many constraints such as the limited incentives for SMEs, weak human and financial resources, weak tools of monitoring and measuring the level of integration achieved, inadequate resources devoted to research and development, the lack of a program of training and R&D, as well as the non-use of patents produced by the industrial and academic sectors. Another constraint lies in the weak mobilization of decision-makers and economic operators to adopt sustainable production and consumption patterns which is explained by the weak sensitization and communication measures, large deficits in green skills and low demand from potential employing sectors.

Economic activities (in particular industrial ones) are not yet classified on the basis of environmental pressures. Indeed, companies do not have information on emission limits, which raises the problem of the

[19] Example: the non-application of Article 23 of the Law on waste management and disposal which creates a fee for the provision of public services.

[20] MEMEE, Département de l'Environnement, Bilan des realizations, 2014.
HCP (2005), Prospective Maroc 2030: Eveil aux problématiques du Maroc de 2030, Rabat.
ADEREE, Stratégie Nationale d'Efficacité Energétique à horizon 2030, Mars 2014.

relationship between the category of industrial activity and the inspections missions. At the level of industry, the fabric is characterized by the small presence of specialized and qualified SMEs in the new environmental sectors, the weak commitment of the majority of professional organizations, the inadequacy of programs and measures to upgrade SMEs and VSEs through trainings and qualification belonging to the strategic sectors identified. The "Industry and Green Economy in North Africa" report, CEA (2015)[21], shows that industrialists are particularly concerned about productivity and economic profitability and that they are not generally equipped to produce green. It also points out that the administration often lacks capacity in terms of pollution control and provides no technical guidance and assistance to industrialists.

Development programs suffer from the lack of monitoring and evaluation. As for industry, for example, with the launch of the new strategy, Morocco launched, in just ten years, three industrial strategies: the Emergence Plan in 2005, the National Plan for Industrial Emergence in 2009 and the recent National Industrial Acceleration Plan (2014). However, when a previously launched strategy is completed, it should in principle be evaluated so that the responsible parties are held accountable in accordance with the provisions of the new constitution.

The informal sector poses a major challenge to the transition to a green economy, particularly in the waste sector that is developing faster than other sectors and whose potential for job creation is greater. It is generally composed of a marginalized population and it plays an important role in the collection and recycling of waste and provides a great service to the community by contributing directly to the reduction of greenhouse gas emissions by providing recycling centers with raw materials. A better organization and more appropriate incentive mechanisms could help to integrate this sector into the formal system.

[21] CEA (2015), Industrie et économie verte en Afrique du Nord: Perception, enjeux et perspectives, Rapport régional, Mars.

2.2. Financing Issues

The success of the programs developed by the State and its partners depends on the financial resources deployed. The promotion of the green economy requires long-term financing in many areas (infrastructure, technology, training, etc.). The bulk of this should come from the private sector, through banks and insurance companies. Nevertheless, the public sector will have to contribute significantly.

Table 3. Major financing funds

Funds	Objectives
• Industrial Depollution Fund (FODEP)	Supporting the upgrading of industrial companies and contributing to compliance with standards for the reduction of pollution related to industrial production.
• National Environnemental Fund (FNE)	Financing actions to protect the environment and sustainable development in sectors other than industry.
• Clean Developpement Mechanism (MDP)	Fighting global warming and encouraging developing countries to make efforts to reduce greenhouse gas emissions by investing in clean technologies.
• Moroccan Carbon Capital Fund[22] (FCCM)	Accompanying Moroccan promoters to carry out their projects by acquiring their carbon credits over the period 2008-2017, in the priority areas: renewable energies, energy efficiency and waste management.
• Energy Developement Fund FDE	Accompanying the new national policy for the development of electricity production from renewable energy sources and energy efficiency.
• Green Investment Plan	Strengthening resilience in the agriculture and water sectors and reduce cumulative emissions by 181 MtCOq2 by 2030.

Recognizing this issue, public authorities have developed financing mechanisms for companies with their national and international partners in order to support them in their sustainability efforts. They have put in place

[22] The FCCM signed in consortium with international partners, a purchase contract with the ONEE on the Tangier wind power project for the acquisition of more than 2 million carbon credits.

several subsidies, known as green subsidies, to encourage the preservation of the environment. These subsidies, considered as financial aid for pollution reduction and environmental protection, are financed by various funds: the National Environment Fund, the Industrial Pollution Control Fund, the Energy Development Fund, Capital Carbon Fund, Efficiency and Renewable Energies Guarantee Fund, Liquid Sanitation and Wastewater Treatment Fund and the recent Green Investment Plan.[23]

Sector strategies are complementary, mainly the Imtiaz program of the Emergence Pact, and supported by the industrial acceleration plan which accounts for 20% of business investment in new technologies, in addition to the Morocco Numeric Strategy which includes several initiatives to develop and finance an information technology industry. A Climate Multi Risk Insurance was launched in 2011 to provide comprehensive coverage to farmers. It concerns cereal crops and legumes throughout the Moroccan and also covers several climatic risks such as drought, excess water, hail, frost, strong winds and sandstorms. Among other things, it set a forecast target of 1 million hectares by 2015[24]. The government subsidizes the product at a margin of 53% and 90%, depending on the level of guarantee retained.

Morocco's ability to facilitate SMEs' access to funding has been relatively well developed, but the financing mechanisms for green investments are currently more concentrated around the state budget with some timid banking initiatives in this area. Banks individually and/or at the level of the Moroccan Professional Banking Group (GPBM) have expressed their willingness to contribute to the financing of the ecological transition. Indeed, some banks are beginning to show interest in designing specific products and creating centers for the SME sector and discuss financing solutions that are more appropriate (attractive interest rates, deferred payment, etc). They also co-finance projects with the State. However, the tools remain very limited and highly conditioned and the banks continue to function globally on the basis of their traditional criteria.

[23] The GIP is prepared with the support of the World Bank and GIZ. Its implementation requires $15 billion USD and around thirty projects are proposed to mobilize additional private sector funding.

[24] Nearly 700 000 hectares are insured for the year 2013-2014.

2.3. Problems of Research- Development and Innovation

Innovation is present in the national sectoral strategies: The Plan RAWAJ, Morocco Numeric Plan, and National Strategy for the Development of Scientific Research by 2025. The State has set up the Moroccan Center for Innovation, the Moroccan Office of Industrial and Commercial Property, the Moroccan Center for Climate Innovation, which offers financing instruments that can be used to support innovative investment projects. The innovative university campuses are reception areas for R&D and innovation activities and innovative companies including public and private R&D centers. Also, the creation of university incubators (since 2002) aims at providing the promoters of innovative projects with a reception platform to meet their needs. Today, 13 university incubators are members of the RMIE, 6 of which are operational. The National Innovation System initiated in 2011 by the Morocco Innovation Strategy consists in defining the concrete measures to foster an innovation environment in line with the competitiveness and the needs of the market.

The Institute for Research in Solar Energy and New Energies (IRESEN[25]) was created in 2011 to support the national energy strategy by supporting applied R&D in the solar energy and new energies field. Morocco has been trying in recent years to promote investments in science and technology to set up campuses that provide knowledge-based services with a view to strengthening research and training in clean technologies. The knowledge campuses are part of a five-year $ 3.2 billion investment plan for renewable energies to enable the development of skilled labor through training programs, conferences, seminars, new masters in renewable energies and through research projects.

Funds have also been created, be they public such as the Public Innovation Fund which offers funding programs (INTILAK, TATWIR) via the CMI and set up within the framework of the SMI for innovative startups promoting innovative projects or R&D valorization projects or

[25] IRESEN was created as part of a partnership between MEMEE, SIE, ADEREE, MASEN, ONEE, OCP, MANAGEM, ONHYM, the Ministry of Higher Education and the Energy Federation.

private, such as Morocco Numeric Fund (MITC Capital), Moroccan Business Angels Network, Moroccan Association for Research and Development (R&D Maroc), Morocco Incubation and Spin-off Network (RMIE[26]), Moroccan Foundation for Advanced Science, Innovation and Research (MAScIR), OCP Innovation Fund for Agriculture, Dayam of the SAHAM Group and Afoulki Invest. These are all means to enable the companies to innovate in terms of products, processes, marketing and business models.

Although the country has made considerable efforts and made significant progress in terms of infrastructure and research and development institutions, the available data show a worrying delay in the implementation of the right measures for the development of research and its contribution to the dynamism of an emerging and innovative economy. The budget allocated to scientific research was 0.8% of GDP in 2013 (0.34% in 2006 and 0.73% in 2010), with the aim of reaching 1% in 2016. The bulk of this budget is used for the benefit of hard sciences and only 7% is devoted to research in human and social sciences.

Morocco is ranked 88th according to the Global Innovation Index 2012 developed by INSEAD and WIPO with only 1.87 researchers per 1,000 people employed (8.3 in France and 10.6 in Japan); 60% of patents pending[27] are made by individual inventors while the rest by companies and universities; 90% of Moroccan researchers are from the public sector. The fields of theoretical and fundamental research are the most privileged. Moroccan researchers are massively present in the humanities and social sciences (38%). Engineering sciences and technology accounted for only 16% of researchers in Morocco in 2010. Almost 80% of companies resort to self-financing to develop their R&D projects.

The scientific research system includes institutes, research units, and post-graduate study centers. The work of the National Center for Scientific and Technical Research (CNRST) has contributed greatly to informing the national policy on strategic sectors such as water management, agriculture

[26] This network includes public and private operators to support the creation of innovative companies based on research results. It annually launches a call for proposals aiming at providing financial support for the creation of innovative technology companies.

[27] Only 200 patents on average are filed each year.

and energy. Yet, the formal basis of research and development in Morocco is very limited and the system is still sub-optimal and very dependent on inefficient public research.

While several green innovations are expected in agriculture, industry, renewable energies[28] with the latest strategies that encourage less resource-intensive and less waste-generating modes of production, funding mechanisms and instruments of innovation do not yet meet the expectations of those who have ideas and innovative projects, either in terms of budget or approach. Of the 14 clusters in Morocco created since 2001, only the Technopark of Casablanca as a private company which welcomes 180 innovative companies (MITC for Moroccan Information Technopark Company), Morocco Numeric Cluster which gathers 42 start-ups and Morocco Microelectronics Cluster are operational.

The involvement of the private sector in the financing of the national R & D endeavor remains marginal compared to the public effort although it has increased significantly over the last 10 years. The lack of effective coordination among the various actors, the absence of a real single window for innovation and the inadequacy of funding for research in the private sector are slowing the pace of the improvement of innovation ecosystem in Morocco, AMIC (2012).[29] In addition, the weak institutional, industrial and financial network of incubators, which lacks autonomy compared to the organization of universities, make it difficult to acquire adequate equipment or expertise for projects.

Boosting innovation is strongly linked to how the system can benefit from the stock of regional and international knowledge and to disseminate modern and more effective practices to the largest number of national users, Djeflat (2012).[30] Nevertheless, some indicators show that the country is capable of integrating technologies in business and is within the world

[28] Innovations in renewable energies are numerous: wind, solar, hydroelectric, solar thermal, wood energy, alternative fuels, agro-fuels, biogas, green electricity, smart grids, short distribution channels between producer and user.

[29] AMIC, Etat des lieux sur le financement de l'innovation au Maroc, 2012.

[30] DJEFLAT A. (2012), Les efforts du Maroc dans l'économie fondée sur la connaissance, Centre de Marseille pour l'Intégration en Méditerranée, septembre. http://cmimarseille.org/ke/docs/EFC%20Maroc-rapport%20documentaire-FR%20March%2021.pdf.

average for venture capital availability, technical journal articles and university-business collaboration for research.

CONCLUSION

The measures taken to strengthen the institutional, regulatory and legal frameworks which have increased the visibility of environmental governance, the adaptation of socio-economic development plans and the numerous environmental programs in addition to the development strategies related to water, renewable energies, energy efficiency and waste have all contributed to making the national context favorable for the development of green to fostering a new dynamic in strategic sectors.

However, the achievements do not yet seem to live up to the efforts and expectations of the actors and the ambitions of the sector programs which foresee a strong development potential for alternative ecological offers. Many major challenges remain to be tackled in a comprehensive and complementary manner in order to take advantage of the ecological transition and more efforts must be made by firms, particularly SMEs.

Indeed, state programs and projects must be integrated into a global and coherent vision of development bringing together the various actors and mobilizing the necessary financial and human resources. This should be coupled with the active participation of all actors not only in terms of application or monitoring and evaluation of the actions undertaken, but also prior to the decision-making process.

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Chapter 5

ENVIRONMENTAL-ECONOMIC-HEALTH COMPONENT CHALLENGES IN A SUSTAINABLE DEVELOPMENT CONTEXT IN MOROCCO

Kholoud Kahime*, Moulay Abdelmonaim El Hidan, Denis Sereno[1], Fatima Arib, Kamar Abaaoukide and Mohamed Messouli
Cadi Ayyad University, Avenue Prince Moulay Abdellah,
Marrakesh, Morocco
[1]MIVEGEC, UMR CNRS-IRD-Université de Montpellier Centre IRD,
Montpellier, France, UMR177, Centre IRD de Montpellier,
Montpellier, France

ABSTRACT

Africa, a continent at the dawn of its development, is therefore the least polluting one. The economic and social well-being of present and

*Corresponding author: kahimkholoud@gmail.com.

future African populations is heavily dependent on good governance and regionalization based on efficiency to meet specific needs and also on mutual assistance. On the other hand, good environmental policy will ensures equitable management of resources, in particular water, forestry, fisheries and agriculture. All African regions, including Morocco have to cope with climate imbalances, population explosion, globalization, exploitation and the management of their resources. The current pattern of consumption threatens people with vulnerability due to its impact on famines, epidemics, damage to biodiversity and natural disasters. Climate change has impact on the development issue and prompt response to support climate change mitigation and adaptation of the African continent, in particular, Morocco. Efforts to address climate change issues date back to the Rio Earth conference in 1992 yet significant deficits still remain. Climate change has had substantial effects on sustainable development. Although the African continent is the least contributor to greenhouse gases, it is the most vulnerable to the adverse impacts of global climatic change due to inadequate adaptive capacity. This vulnerability represents therefore a real obstacle that limits and blocks any development through major consequences, such as high water stress, socio-ecological and economic problems, food and water security, uncontrolled migration, peace and health. Despite de development of a strategy of sustainable development, Morocco remained one of the most affected African countries, in particular on health issues. If in the past, the health of individuals was considered just as an indicator of physical and mental well being. Today, in the context of sustainable development, health must be seen as the result of interactions between the biophysical, social and economic environment. If health disparities are blatant, the country development is neither stable nor safe, but health alone is not enough to make the world just. Against this background, Morocco must have the highest interest in a functional governance framework which has the capability to improve its strategy of sustainable development.

In this study, we will: 1) focus on sustainable development strategy adopted in the kingdom; 2) concentrate on the economic, social and health system components as health determinants, and finally discus relationships between health- sustainable development and climate change. We dress recommendations aimed to build an open, productive and healthy society.

Keywords: health, environment, economic, social, sustainable development, climate change, Morocco

INTRODUCTION

Health, environment and development are distinct but interrelated concepts. Each of these concepts has experienced a number of changes and evolution. In spite of the very ancient connections between them.

Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity (WHO, 1946). This definition of the World Health Organization (WHO) has not changed since 1946. It implies that all basic needs of the person are met, whether emotional, health, nutritional, social or cultural, and from the embryo stage (even gametes) to that of the elderly (WHO, 1946).

According to the WHO, health concept takes into account the environmental, social, psychological and physical aspects and is based on promotion, education and prevention. A healthy environment is the key to better health (Broussouloux & Houzelle, 2006). From this consideration comes the new concept of "health environment" that have emerged in France. It refers to "all the interactions between man and his environment (natural, constructed or to be constructed) and the health effects related to living conditions and contamination of different environments (water, ground air); Living conditions in which people are born, grow, live, work and age (WHO, 1999). "These interactions are diverse and protean. This definition is both arduous and very broad, and for that reason it tries to understand the links between two terms that are already complex in themselves.

Sustainable Development focuses on conservation and management of resources for development (pollution control, biological diversity preservation), as well as social and economic development (fight against poverty, changes in consumption patterns, demographic dynamics, health)".

Thus, health is at the heart of sustainable development, the challenge being the interdependence between environmental degradation, respect for social aspects, development processes and health. According to Dubos (1965) "a healthy individual is one who is able to function as efficiently as

possible in his environment". This makes good health a key to a certain and sustainable development.

In this chapter, we deal with the determinants of health, the environment, the sustainable development strategy, all their interrelations, interactions, complementarities and impacts. Here we focus on Morocco as example.

1. HEALTH DETERMINANTS IN MOROCCO

Country social and economic development level is closely linked to the health status of its population, in other words, health is an integral part of development, as individuals contribute to the development of the country in which they live and take advantage of it **(**Wilkinson and Pickett, 2006). On the one hand, economic and social progress has a positive effect on the health of the population. On the other hand, the human energy generated by improving the health of the population contributes to social and economic development.

The "social" nature of health was recognized at the Alma-Ata Conference on Primary Health Care in 1978 (Bloom andCanning, 2000). According to the declaration adopted, health is not simply the absence of disease or infirmity. Rather, it is a state of physical, mental and social well-being - the threshold under which individuals can not enjoy a physical condition that enables them to lead a socially and economically productive life. Thus, alongside the three basic determinants of housing, income and food, there are many other factors that influence good - or poor health: education, environment, family, Labor ... Moreover, the determinants of health vary considerably according to the economic level of each country. Table 1 shows the main determinants of health in the Eastern Mediterranean region, including Morocco (EMRO, 2014). Figure 1 depicts that major determinants of health in Morocco are from socio-economic factors (EMRO, 2014).

Indeed, unfavorable socio-economic conditions affect health for life. People at the bottom of the social ladder are at greater risk of serious illness or premature death than those near the top. Over the past decade, the focus on health equity and social determinants of health has grown in importance (Figure 1).

In 2005, the World Health Organization created the Commission on Social Determinants of Health (CSDH), which published its interesting report in 2008 entitled "Bridging the Gap in a Generation: Health Equity Through Action On the social determinants of health ". The report states that "the social determinants of health are the conditions under which people are born, grow, live, work and age, including the health system" (Table 1).

In developing countries like Morocco, with its striking social inequalities and obvious regional differences, the links between health and social factors take on even greater proportions. Subsequently, we will limit our analysis to the main social determinants of health for which data are available in Morocco.

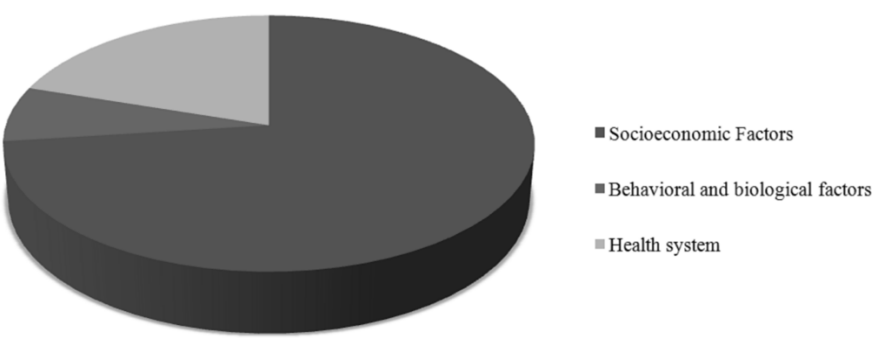

Figure 1. Contribution of major factors (socioeconomic: 73%; behavior and biological: 20%; health system: 7%) to inequalities in births attended by skilled personnel, Morocco, 2001 (EMRO, 2014).

Table 1. Key public health determinants identified in the Eastern Mediterranean region, adapted for Morocco (EMRO, 2014)

Major Factors		Wealth	Water and sanitation	-Prenatal care
	- Place of residence (urban / rural) - Region (province, town) - Legislation - International Conventions	Education	Media exposure	- Care access barriers - Prevention - Care and personnel availability
		Occupation	Biological characteristics of child (age, sex, birth weight, morbidity)	
		Other social characteristics (gender, social behavior, lifestyle, customs...)	Mother biological characteristics (age, birth interval, height, body mass index)	
			Child care practices (method of stool disposal, length of time breastfed, types of food fed to child, vaccinations received by child)	
			Competition for resources	

A) Socio-Economic Issues

1) Education and Literacy

Several studies indicate a strong association between the patient's health literacy level and different health issues (Kalichman et al., 2000, Schillinger et al., 2002). In Morocco, according to the National Agency for the Control of Illiteracy, about 10 million people, or nearly one third of the population, are still illiterate. Nevertheless, the primary enrollment rate has improved significantly in terms of average indicators and inequality reduction, reaching same rate (94.5%) for girls and boys in 2012. Difference between urban areas (96.9%) and rural (91.6%) are still present in Morocco. Unfortunately, the primary school enrollment rate is not maintained at the college, which represents only 49.4% of rural girls (Figure 2) and decreases at the secondary level, where the national rate decreases to 45.8%, with only 16% In rural areas (19.3% for boys and 13.1% for girls) (Yaakoubd, 2009).

2) Young Children Health and Social Inequalities

Often considered as one of the indicators of socio-economic development and well-being, infant mortality is also frequently used as one of the best general indicatorof the health status of a population. Indeed, the first years of a child's life are those in which his health and his chances of survival depend most directly on the social and economic status of his parents (Yaakoubd, 2009). It is also the age when the effects of different treatment by gender are most felt in terms of child health, especially that of girls.

Figure 3 shows that social and economic differences in Morocco are mainly expressed in terms of post-neonatal mortality. This is other proof of the influence of the social and economic context on the health of Moroccan children and the chances of survival. In terms of post-natal mortality a higher level is reported for the poorest. The mother's level of education appears also to be one factor having an impact on the rate of infant mortality, so a marked rate decrease in noticed when the mother's level of education rises. Another factor that may have an effect on child mortality

is the residence location. As long as a higher mortality rate is observed in rural areas as compared to urban ones. Actions of the different socio-economic factors can be explained by a number of causes, the main ones being hygiene, food and care.

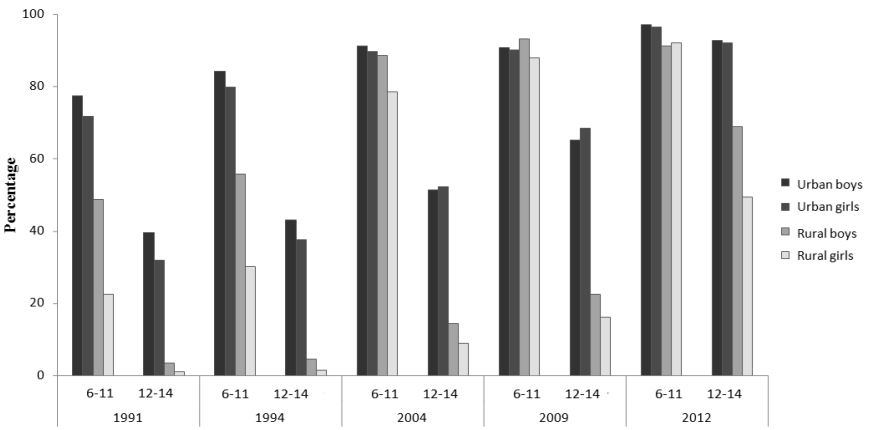

Figure 2. Evolution of primary (6-11 years) and secondary (12-14 years) enrolment.

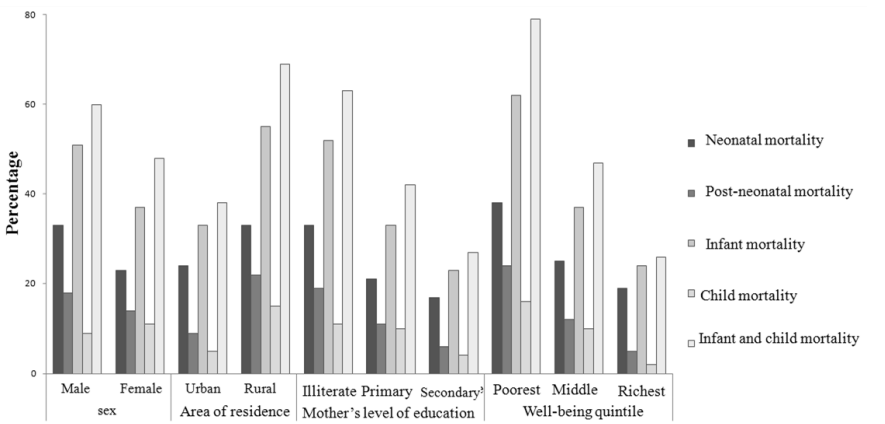

Figure 3. Relation between child mortality rate and specific some socio-economic characteristics (PAPFAM, 2003-2004).

B) Health System Issues

1) Health Coverage

Health coverage aims to achieve better health and development outcomes, help prevent people from falling into poverty due to illness, and give people the opportunity to lead healthier, more productive lives. By the end of the second millennium, the national health insurance coverage did not exceed 15% and more than 30% of the population was unable to pay the necessary medical care. However, in recent years and in order to compensate for this great lack of assurance, the government has opted for mandatory health insurance (AMO) for public and private employees, which started in 2005. In addition, an assistance program for the poor (RAMED) was implemented nationally in 2011 and student insurance (SI), which was also approved by parliament in 2015. According to the Ministry of Health, health coverage that was of 60% of the population Morocco in May 2015 is expected to reach 92% with the continued implementation of medical insurance for the self-employed, which is expected to cover 11 million people.

2) Accessibility to Services and Health Care

Key factors in assessing access to health care and services include skilled birth attendance, prenatal visits, postnatal care and infant vaccination. In Morocco, access to health services and health care has increased considerably in recent decades, as shown in Table 1. Indeed, the percentage of deliveries attended by skilled personnel rose from 31% in 1992 to 73.5% in 2011. Similarly, the percentage of women who had at least one prenatal visit increased from 33% to 77.1% over the same period. Postnatal care has also increased, but remains low (21.9%). The prevalence of vaccination of infants aged of 12 to 23 months increased from 75.7% in 1992 to 87.7% in 2011, respectively.

However, some of these indicators such as antenatal care, assisted delivery and postnatal visits vary considerably depending on the place of residence, the mother’s level of education and the social category. Table 2 summarizes the latest national survey of population and family health

carried out by the Ministry of Health in 2011, with the proportion of skilled attendant deliveries in urban areas (92.1%) almost twice as high rural areas (55%). Similarly, women with a primary certificate (99%) are more likely to be assisted by qualified staff than unqualified women (66%). The probability of childbirth attended by skilled personnel is 2.5 times higher in the richest category of the population (96%) than the poorest (37.7%).

Table 2. Access to health care in Morocco between 1992 and 2011 (ENPS, 1992; ENPSF, 2011)

Health and / or health care services		1992	2011
% Of birth attended by skilled personnel	Urban	64	92.1
	Rural	14	55
	National	31	73.5
% Of women with at least one prenatal visit	Urban	61	91.6
	Rural	18	62.7
	National	33	77.1
% Of women with postnatal visits Urban	Urban	-	30.5
	Rural	-	13.3
	National	-	21.9
% Complete vaccination coverage for infants aged 12-23 months	Urban	93.7	93.5
	Rural	66.7	82.6
	National	75.7	87.7

Actually, while the capacity to act on diseases and health problems is growing considerably, the issue goes beyond human biology and becomes more complex: in the field of health, psycho-cultural factors, the ecological environment, socio-cultural, economic and physical factors, as well as access to quality health services and social services.

In the context of sustainable development, a new strategic vision for health must therefore be adopted. These interventions will alleviate poverty and improve the living conditions through more equitable access to resources. The efforts to be made for judicious use of resources in a healthier environment are still as intense.

2. SUSTAINABLE DEVELOPMENT STRATEGY IN MOROCCO

According to Bruntland Report (1987), sustainable development present needs without compromising the ability of future generations to meet their own needs. Since then, the concept has become a key theme in any political, economic and social debate, to protect the environment, ensure economic growth and social equity. In accordance with its international commitments in the framework of the Earth Summit in Rio de Janeiro (1992) and Johannesburg (2002) and the relevant Conventions, Morocco has put in place the foundations for sustainable development in the country; through several political, institutional, legal and socio-economic reforms. This process was reinforced by the adoption of the National Charter for the Environment and Sustainable Development (CESD) in 2009.

In Morocco, Environment is in constant degradation and natural resources are dwindling regularly. Environment protection requires a global vision, an efficacious mobilization of financial and human resources, technical expertise and an individual participative approach. It also requires an institutional and legal framework to tackle resource misuse, polluters and positive incentives for industries that agree to subscribe to a clean sustainable development.

The concepts of sustainable development and corporate social responsibility are invading public policies. They are increasingly influencing business decisions, regardless of the economic activity or sector, and they challenge citizens and public opinion. The implementation of sustainable development approaches concerns mainly large companies, including drug companies and major groups but also manufacturers of hospital equipment. However, small and medium-sized enterprises (SMEs) are increasingly confronted to these concepts, whatever their field of activity.

Morocco has signed and ratified the main international and regional conventions on the environment and sustainable development. Among

these international commitments is the elaboration of a National Sustainable Development Strategy (NSDS, 2014). At the Rio Summit in 1992, under Agenda 21, States committed themselves to developing an NSDS that was to be "inspired by the various sectorial plans and policies, to blend them into a coherent whole, to achieve equitable social progress while preserving the resource base and the environment for future generations.

Despite its efforts to anchor the principles of sustainable development, Morocco still faces challenges like: the continued increase in energy or food prices, the adverse effects of climate change, the loss of biodiversity, the depletion of natural resources and the widening of social inequalities. Thus, concrete implementations remain modest and very difficult.

To confront these challenges and achieve the intergenerational goal of sustainable development. According to the SNDD (2014), it is essential to secure a certain number of fundamentals to ensure a sustainable trajectory based on the integration of the 4 fundamental pillars of sustainable development (Figure 4).

The economic pillar is undoubtedly the locomotive vision of the concept, because without a sound and efficient economy no sustainable development is possible. This economy must ensure a better integration of socio-environmental considerations. Moreover, a real economy of the environment is possible through the implementation of a circular economy, or even green industrialization.

The social pillar needs to be strengthened, including health-related policies which, despite improved indicators, remain far below targets and expectation to ensure human development.

The environmental pillar shows that the actions are mainly curative and respond to emergencies. In fact environment has never been identified as a source of sustainable growth.

Finally, the cultural pillar, allows to define a strategy based on the specificities of Morocco.

The relationships and interrelationships between all these different pillars affect the health status of the population in a favorable or unfavorable ways.

Figure 4. The pillars of sustainable development in Morocco (modified) (SNDS, 2014).

Relationships between health and sustainable development are numerous and narrow. There is no doubt that sustainable development and corporate social responsibility will increasingly influence decisions and positions of decision-makers. Mismanagement of waste (about 6 million tons per year in Morocco) is responsible for all types of pollution (atmospheric, chemical and biological), water resources (superficial or underground), deterioration in the quality of life in urban areas, soil contamination by hazardous products (pesticides, heavy metals), pollution of the littoral and the marine environment (CDURABLE, 2017). All of these negatively impacts human health.

3. RELATIONSHIPS BETWEEN HEALTH- SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

The economic and social well-being of the present and future population are heavily dependent on good governance, and on a regionalization based on efficiency to meet specific needs and mutual assistance. On the other hand, good environmental policy ensures equitable management of resources, in particular water, forestry, fisheries and agriculture.

Most African regions face climate imbalances, population explosion, globalization, unsustainable exploitation and management of their resources; current pattern of consumption threatens to vulnerability, famine, epidemics, damage to biodiversity and natural disasters (Intergovernmental Panel on Climate Experts (IPCC), 2014).These are real obstacles that limit and block any development through major consequences, such as high water stress, socio-ecological and economic problems, food and water security, uncontrolled migration and peace.

Individual health was considered just as an indicator of physical and mental well being. Recently, in the context of sustainable development, health must be seen as the result of interactions between the biophysical, social and economic environment.

Worldwide, and according to World Health Organization (WHO), the number of natural disasters related to meteorology has more than tripled since the 1960s. Each year, more than 60 000 deaths have occurred, mainly in developing countries (WHO, 2017). In Africa, rising temperatures and precipitation fluctuations have and will have an impact on food production in many of the poorest regions, leading to malnutrition, food and water insecurity (IPCC, 2014).

Towards climate change, the IPCC reports (2007, 2014) state that developing countries will be the first victims and the hardest hit. As global warming progresses, the effects of extreme weather events will be sudden and severe (Suk & Semenza, 2014).

It should be noted that, the issue of health-climate change was not well discussed at the previous conferences of parties (COPs). It was only at

COP 21 that health was mentioned as highly vulnerable to climate change. This is based on the report of the Intergovernmental Panel on Climate Experts (IPCC). Expert Scientist may make projection scenarios and forecast models, combining disease occurrence and climatic parameters only if adequate tools are at their disposal.

In Morocco as well as in numerous African regions, agriculture remains the major economic activity. In rural areas, many survive on a day-to-day basis through subsistence farming, with no surplus. According to the World Health Organization, in some African countries, crop yields are expected to fall by 50% by 2020, (WHO, 2016). Climate change affects the social and environmental determinants of health: directly by the disruption of climatic parameters (Temperatures, Precipitation and extreme events) and indirectly through their damage and consequences on the soil and the water cycle more specifically. The increasingly aleatory nature of precipitation will also impact water supply. Lack of safe water can compromise hygiene and increase the risk of diarrheal diseases, which kill annually nearly 600,000 of children fewer than five years of age (WHO, 2016). Flooding also increases in frequency and intensity, thus contaminating freshwater sources that increases the risk of water-borne diseases and creates breeding sites for insect vectors of medical and veterinary importance like malaria or leishmaniasis.

High temperatures or searing heat contribute directly to mortality from cardiovascular and respiratory diseases, especially in the elderly. Concentrations of pollen and other aeroallergens increase in high heat. They can trigger asthma attacks, a disease that affects about 300 million people worldwide (WHO, 2016).

All these examples tend to show that health is the most vulnerable sector that makes human and social capital very fragile. The good health of a population contributes to social cohesion and peace. A world where health disparities are blatant is neither stable nor safe, but health alone is not enough to make the world just. On the other hand, a country's economic development does not necessarily protect the poor, nor does it guarantee universal access to health care.

Currently, most international trade and economic agreements do not take into account health consequences. Thus, in the health sector that we must defend equity and social justice. It is therefore crucial to concentrate on economic, social and ecological components of health, for the vulnerable segments and for the population as a whole, with a view to build open, productive and healthy societies. We must therefore advocate for the full realization of the right to the enjoyment of the highest attainable standard of physical and mental health. In addition, a healthy environment is a prerequisite for good health, and it is clear that the links between health, environment and sustainable development are of paramount importance.

With this in mind, in September 2015, the 193 Member States of the United Nations (UN) agreed to achieve some 17 sustainable development objectives (SDGs) by 2030. Virtually all have a health component or contribute to improving global health.

The UN's third objective is specifically dedicated to health and well-being. It aims to "enable all to live in good health and to promote the well-being of all at all ages".

This new program, which extends the Millennium Development Goals adopted in 2000, aims to be relevant to all countries. Its major aim is to combat inequalities and to give priority to the women needs, to children, to the poorest and the most disadvantaged persons.

Indeed, health may be at the origin of an economic slowdown. Malaria, in African endemic countries, has caused a slowdown in the economic growth of up to 1.3% per year (WHO, 2016). In other cases, poorly managed development processes, causes a degradation of health. This is the case when development is accompanied by migratory movements and too fast metropolisation phenomena (the case of slums difficult to manage / Mastering). These generate more poverty and injustice.

Health is therefore a major concern for sustainable development, as outlined in Principle I of the Rio Declaration on Environment and Development in 1992: "Human beings are at the center of sustainable development concerns. They have a right to a healthy and productive life in harmony with nature.

The follow-up program of Agenda 21 following the Rio conference has set five priority public health objectives. These are: meeting primary health care needs; communicable diseases, protection of vulnerable groups, health of urban populations, and reduction of health risks caused by pollution and ecological threats.

In the context of sustainable development, health is an objective, but also a prerequisite. The goal is to provide people with satisfactory physical and moral well-being and to guarantee sanitary conditions which enable the productive activities and sustainable development of their society. According to the WHO Director, when they are healthy, people are better prepared to learn, to be productive and to contribute effectively to the life of their community (WHO, 2016).

Sustainable development is an intergenerational and qualitative approach to the evolution of societies, according to which it is important to bequeath to future generations an ecological, economic and social environment at least as good as today.

In terms of health, this concept of sustainable development means reforming health systems so that they are more responsive to the needs and budgetary capacities of each region. Contrary to the temptation to shift health and education budgets to reduce public spending, it is necessary to consider that educated and healthy individuals are the true locomotive for all development. It is therefore a matter of keeping the public health budget within acceptable limits and developing new forms of agreements between private and public sectors.

At present, while our capacity to act against diseases is growing considerably, the question goes beyond human biology and becomes more complex: in terms of health systems, lifestyle, ecological, socio-cultural and economic environment. Physical health is now considered as a determining factor, along with access to quality health services and social services. A new vision of health needs to be adopted in order to be able to intervene effectively to improve the health and well-being of individuals and populations (Kahime et al., 2016). Recognizing that human health is intimately linked to ecosystems, the new paths of research field charting towards a more sustainable future. An ecosystem approach to health is

adopted. This approach combine diverse fields such as environmental management, public health, biodiversity and economic development (Hancock, 1990).

Ecohealth is based on the belief that human being is an integral part of a complex socio-ecological system (Kahime et al., 2016). This ecosystem approach places as much emphasis on good environmental management as economic factors and community aspirations in resource management. The need for good governance and better inter-sectorial coordination is essential in order to improve the living conditions (habitat and sanitation of the population) and to reduce any risk for health.

CONCLUSION

In Morocco like the other countries of the African continent, development is compromised by many socio-economic and ecological problems. Citizens, NGOs or political parties are strongly challenged to solve them.

Good health of the population is a driving force for development, but health is a vulnerable sector for the majority of African areas, including Morocco. The solutions to be undertaken must ensure, among other choices and in the context of sustainable development, the health of the citizen; ensuring a healthy environment, a pleasant living environment, sustainable access to water, efficient waste management and protection of soils and forests. Nevertheless, health gaps persist between environments and between regions, which are a brake for the development of health in Morocco.

The health-related development issues that need to be addressed, in Morocco and elsewhere in Africa are:

- Access to better energy services and develop sustainable and healthy solutions to reduce air pollution and thus significantly decrease the number of cardiovascular and respiratory diseases;

- Increased interest in various planning measures for durable habitation and transport: such as housing construction and the adoption of more sustainable and energy efficient transportation, which significantly shrink diseases due to air pollution and indirectly traffic accidents;
- Improving sanitation in towns and villages to prevent the spread of parasitic diseases;
- More sustainable food systems to combat hunger and contribute to improved health and nutrition;
- More sustainable use of water that meets basic drinking water needs and allows for good management of water resources especially for agriculture;
- Ensuring that minimum health and safety standards are met for all jobs to reduce the number of cancers, chronic respiratory diseases, trauma and premature deaths.

In the other hand, establish forecasting models combining the impacts of diseases and climatic parameters but there are many problems:

- Lack of measurable climatic data with the need to create an international database for comparison purposes;
- The complication of ethical questions and authorizations
- Lack of a systemic approach to manage health problems and implement climate change adaptation policies in a sustainable development context;

Improving the resilience of populations' health will require:

- Establish adaptation strategies, including infrastructure improvements, training of personnel, medicines, systems and quality of care, medical insurance with good governance.
- Mitigation strategies will reduce air pollution and therefore reduce respiratory and cardiovascular diseases

- Mobilize more funds to improve health systems
- To sensitize and mobilize the players in the health sector and to develop an approach to a spirit of humanitarian and solidarity medicine
- Develop a well-adapted intervention policy and monitoring systems.

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Chapter 6

EMERGENCY AND TIME MANAGEMENT IN MOROCCAN SME'S

KamarAbaaoukide*, *, Fatima Arib and Kholoud Kahime*
Cadi Ayyad University, Marrakesh, Morocco

ABSTRACT

The world is experiencing today a period of deep change whose pace is on growing. It lives in a period of instability heralding the advent of a society marked by the uncertainty and the turbulence. Currently, the consideration of environment and the necessity to react quickly are required. The importance of those elements is linked to the subjective perception. This latter is even more palpable through the focusing of the leaders on two aspects of the environment namely and uncertainty.

Managing in these conditions becomes a constant worry within companies. Those latter are obliged to do the maximum in record time to stay ahead of competitors. So, managing in emergency becomes a new rule not an exception any more.

The rise of the emergency concept reflects a mutation that took place when the speed correlated to the conquest of space (new markets), has integrated the time. This emergency has invaded the organizations. It is

*Corresponding author: kamar_kam@yahoo.fr; kahimkholoud@gmail.com.

consistent with the context of globalization and increased competition that need quick responses.

The emergency to act touches almost every aspect of business: its nature, its location, the price, the distribution system, the personnel policies… Hence, it is important to learn about the various components of the emergency in which the business has to operate in order to run a business unit successfully.

Moroccan SMEs, representing more than 80% of Moroccan firms, live under multiple constraints and transformations. The interaction between these companies and their environment leads to inevitable pressures making them unimmunized. These SMEs are influenced by the contingent factors and competitive pressures that condition their performance. They are faced to the economic globalization and the need to integrate the emergency to all their actions and to conserve their market place.

These companies seem caught in a paradoxical movement: they would like to think under the sign of the project and anticipation, in the same time they are forced to manage the emergency. They are concerned by the obligation to stay alive with all the environment constraints. Then, how they can face with the pressure of time and integrating the emergency into their management?

While little research has been devoted to it, we will clarify the theoretical concepts underlying the notion of the emergency and the time pressure. We will appeal the exploration through a qualitative approach and use individual interviews with Moroccan SMEs' managers in the empirical study in order to answer the question.

Keywords: emergency, time, environment, management, Moroccan SMEs, qualitative approach

INTRODUCTION

Brings to mind Samuel Johnson's remark: "when a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully''; this quotation illustrates perfectly the dilemma faced by managers with the rise of the notion of sustainable development and the pace of enormous changes caused by the environment. The realization of profit and opportunistic logic are called into question. The integration of economic development and the preservation of the environment have become

inseparable. It's now urgent to integrate this new perspective to stay on the competition.

In a world deemed to have change as a fundamental logic, managers face new challenges: they must manage their businesses, make engaging decisions to preserve the environment; and at the same time they are obliged to have quick and immediate answers to face the frenzied race to change.

ISSUE

Nowadays, the world is undergoing a period of deep change whose the rhythm is constantly increasing. It lives in a period of instability which is a sign of the advent of uncertainty and turbulence.

Powerful upswing in the emergency to be aware about the environment's evolution within companies reflects that a change has taken place. The emergency of integrating this variable is in line with the context of globalization requiring rapid responses to the constraints of the environment.

Moroccan companies are faced to the economic globalization and the need to integrate the environmental variable into all their actions. These external pressures force them to grow in order to conserve their market place.

Those companies seem taking a paradoxical step: they would like to think themselves under the sign of project and anticipation, and they have to manage environmental constraints (Laidi, 1999). In this context, SME may appear to be the most vulnerable due to their lack of capacity. They are subject to the constraints of the environment (Julien and Marchesnay, 1987) and their most appropriate strategies are those of adaptation.

SME, representing more than 80% of the Moroccan firms, live under multiple constraints and transformations. The interaction between these companies and their environment leads to inevitable pressures making them unimmunized. These SME are influenced by the contingent factors

that condition their performance. They are subject to competitive pressures.

Then, how they can, in addition, face the emergency of integrating environmentalist constraint into their management?

This question can be divided into three questions:

- The integrating environment in SMEs' strategy is a choice or an obligation?
- What is the link between strategy and environmental constraints?
- What is the impact of integrating environmental into company performance?

CONCEPTUAL FRAMEWORK

It isn't easy to define the environment. It can be regarded as the whole of the elements directly or indirectly influencing the organization.

1. The Importance of the Environment

Different approaches integrate the environment to situate the company in the context of pressures and changes that constrain its management system (Sainsaulieu, 1990). It is an explanatory factor for the strategy's performance. The environment is a set of external pressures in which the firm is positioned in various forms and levels (Sainsaulieu, 1985). It is considered as the most influential factor in strategic choices (Gueguen, 1997).

The environment is composed by a variety of interdependent variables, varying in degree of presence or absence, gravitating outside the organization, and possessing potential for influence (Marticotte and Perrien, 1995). Today, we are talking more about sustainable development

and the need to integrate the three aspects: economic, social and environmental.

According to Marchesnay (1982), we can distinguish between: a macro, a meso, and then a micro environment. Marchesnay (1993) defines macro-environment as the set of structural elements that frame the major choices of the firm; it regroups the set of societal variables. The meso-environment represents substitute products, production chains and the local environment; while the microenvironment brings together all the direct partners.

SME are focused primarily on their close environment. Their efforts are directed to the proximity not to the environment seen in a broader sense (Creton, 1986). This latter is characterized by a high degree of turbulence, complexity, uncertainty and dynamism that can jeopardize the SME's sustainability.

Turbulence

Turbulence is defined as a state of the environment involving a loss of control over the future of the company (Joffre and Koenig, 1985). The turbulence level depends on the magnitude and frequency of change. For Ansoff and Mac Donell (1990), the turbulence represents variability in an environment characterized by a degree of novelty and challenge as well as speed of their development.

The Complexity

Today, the reality which facing the company is complex that prevents from fully understanding and explaining its structure and dynamic.

The evolution of environmental change is neither unique nor known in advance with certainty. The sequel of events carries the germs of rupture, denial and deviation (Smida and Ben Haj, 2005).

Complexity is represented by a number of rather heterogeneous external factors (Dess and Beard, 1984). This description underlies the idea of quantitative complexity (number of factors) and qualitative complexity (dissimilarity of factors). According to the quantitative point of view, the greater the number of environmental factors that must be taken into

account in decision-making, the more complex the environment. According to the qualitative point of view, the more heterogeneous and interactive the factors, the more complex the environment (Weitz and Anderson, 1989).

Uncertainty

It reviews to the inability to quantify the impact of environmental change. Uncertainty is related to the lack of information about environmental factors, making forecasting impossible.

Complexity and turbulence reinforce the degree of uncertainty. The latter is linked to the lack or failure of information that makes impossible to predict the impact of environmental factors on the organization or to make definitive decisions since it is difficult to know the outcome.

Turbulence also implies the difficulty of predicting. Cameron, Kim and Whetten (1987) estimate that turbulence creates uncertainty. Turbulence would be an abstract concept, while uncertainty would be operationalized.

The Dynamism

It leads to the absence of models by reinforcing the unpredictable nature of the environment (Dess and Beard, 1984). It is distinguished by the degree of change or variation in the factors that make up the environment (Bourgeois, 1985). Generally, dynamism may be related to market growth, changes in competitive structure or technological change. It should be emphasized that the frequency of changes and unpredictability are two different things because any change is not necessarily unpredictable. At the level of our theoretical framework, we have used two trends: the deterministic and voluntaristic.

2. The Main Contributions of the Deterministic Trend

Within the framework of the deterministic trend, SMEs are considered as companies with specific management modalities characterized by a lack

of resources (Financial, Human ...) which suggests that they undergo their environments and the situations in which they are evolved.

The environment influences the company in its strategic choices because of the external variables that are taken into consideration (law, scarcity of resources, etc.).

In other words, SMEs are constrained to respect the requirements in order to carry out a strategy in the face of the urgency of integrating the environmental variable.

Thus, the main contribution of this trend is the urgency of taking into account the environment in the management of the company. The theories of this trend are: the theory of contingency, the theory of resource dependence and the ecology of populations.

The Contingency Theory

One of the specificities of the contingency theory is to think life of organizations as many variables which form between them coherent sets. Contingency is, moreover, defined as a specific and evolutionary situation which leads to the rejection of unique and standard prescriptions (Pichault and Nizet, 2001).

According to the theorists of this school as Donaldson (2001), the current contingency highlights three main axes: strategy, environment and organizational structure. The school of contingency proposes to connect these different elements in order to promote the adaptation. Thus, the first concern of the company's strategy would be adaptation to the environment (Desreumaux, 1992).

The Theory of Resource Dependence

For this theory, which was developed by Pfeffer and Salancik (1978), the environment is the major constraint for organizational action. The vulnerability of an organization arises from its need for resources: raw materials, labor, capital, equipment and markets for its products. This dependence gives the environment power to impose its requirements on business.

The Ecology of Populations

It was developed by Hannan and Freeman (1984). It also assumes that organizations depend on their environment. It gives the latter a considerable power over these organizations. This theory is placed from the point of view of the environment that is assumed to have the power to select from a group of competitors, the companies that best meet its needs.

3. Emergency Management Based on Responsiveness

In the context of the deterministic trend, SMEs must have an attitude to react quickly. This reaction capacity is called by Gueguen (2001): reactivity. He defined it as the ability to present a change in response to external action.

SMEs will try, within the framework of the deterministic trend, to react as quickly as possible in order to have the best result. They will adapt a defensive position. To do this, they must be flexible.

The reactivity or the reaction is defined by Véran (1991) as a compromise; it implies a will to put things in order, this latter is constrained by a pre-existing structural arrangement and its implementation is conditioned by limited cognitive capacities. Véran (1991) also studied the time of the reaction by mentioning the existence of a triggering event that allows the accelerating decision-making process.

The triggering event refers to the phenomenon of catalysis defined by Laszlo (1992) as a thought about processes. This author supports the idea that companies are constrained by a turbulent environment to act faster than in the past with a strong coherence in their strategic choices.

4. The Main Contributions of the Voluntaristic Trend

While the deterministic trend emphasizes the importance of the responsiveness of SMEs to the urgency of protecting the environment,

voluntaristic perspective recognizes the capacity of these companies to be proactive.

The voluntaristic trend brings together several theories; the most important of those are the theory of strategic intent and the theory of resources and skills. Their main contributions are: the relativization of the permanent recourse to adaptation and the recognition of the freedom of action that can go beyond reactivity alone.

The Theory of Strategic Intent

The notion of strategic intent emerged in 1980 as a reaction to the determinism of industry inherent in the classical approach.

Its main authors are Hamel and Prahalad (1989) who proposed a conception of the strategy radically opposed to adaptation: a company can transform the conditions of the environment.

This notion emphasizes a fundamental characteristic: the strategic vision. It represents what the company aspires to become in long term. It is a question of positioning itself in relation to a desired future than in relation to an extrapolation of the present.

The vision is characterized by its excess and deviance, which are supposed to place the company in a situation of lack of resources. This deficiency produces a leverage effect through the multiplication resources' uses.

This vision creates a vacuum between the present and the future, a feeling of dissatisfaction and incompetence that only radically innovative strategy can fulfill. Indeed, this vision is at the origin of the process of transformation of the environment because it lets the firm to change the traditional response registers (Hamel and Prahalad, 1989).

The Theory of Resources and Skills

The resource and skills theory provided an analytical framework to understand how companies can deploy resources to achieve their goals. Within the framework of this theory, the authors distinguish the resource from the skill.

The resource is seen as an observable tangible or intangible asset, while skill refers to the ability of a set of resources to perform a task or activity (Grant, 1996). Companies are considered to be different collections of physical assets, intangible assets and skills.

So, the company will succeed in imposing itself if it holds the appropriate resources for its strategy.

Initially, the firm's resources are grouped into three categories (Barney, 1991): physical resources, human resources, and organizational resources. The building of a sustainable competitive advantage depends on the resources that must be heterogeneous, immobile, rare and not imitable.

Grant (1996) has supplemented this list of resources with another component: the reputation of the company that is built over time in close relation with the stakeholders.

The voluntaristic trend has relativized the determinism that SMEs undergo their environments because of lack of resources. In other words, SMEs can develop strategies outside the constraints imposed by the context.

According to Marchesnay (1993), it is necessary to focus on the relationship of the small enterprise with its local environment which will depend mainly on the psychological profile of the owner-manager.

In this case, SMEs can no longer be considered only as small structures under constraints. Gueguen (2001) thinks that SMEs can differentiate themselves from the influence of their context because the strategic vision of the entrepreneur leads to make his SME’s value.

5. An Anticipatory Management of the Environment

Within the framework of the voluntaristic trend, SMEs are considered as having the capacity to control all the constraint situations in which they operate.

SMEs will try, within the framework of the voluntarist trend, to act before the occurrence of urgent events; they will take an offensive position.

According to Gueguen (2001), the voluntarism of SMEs can be considered as the proactive nature of strategies. Due to the change rhythm and the emergency dominance, SMEs are forced to face unforeseen problems, even imagining original ways to address them. Hence, we can conclude the importance of proactivity to examine the distant future and at the same time anticipate the rapid changes.

Proactivity dispels the fatalism stuck to SMEs, recognizing their freedom to imagine and work for the future. The intent strategy is the ability to develop strategy based on vision and motivation other than the environment's constraints.

The anticipation and the proactivity in an organization presuppose a particularly dynamic manager, able to stimulate the organization in its information research and to synthesize the latter in order to arrive at the opportunities. The organization is often overwhelmed by information of all kinds coming from both internal and external.

Having an organization able to sort and transform information into knowledge takes time. Some managers are able to emerge from daily life to play a key role in the discovery and application of new opportunities. They develop a particular experience to look for and apply these ones (Julien and Vaghely, 2008).

The Methodological Approach

Following our theoretical reflection, it was necessary to use an exploratory study to carry out this research.

An exploratory orientation is necessary in order to fill the lack of theories on the subject. Contrary to the test in which the researcher tests reality with a theoretical object, exploration makes possible to create new propositions starting from an empirical investigation. At the level of our research, we used exploration through a qualitative approach. This one aims to give meaning and to understand the complex social and human phenomena.

Miles and Huberman (2003) have shown qualitative analysis as a mode of research able to account for phenomena in their richness and complexity, to regard reality as a human construct and to recognize subjectivity as being at the heart of social life.

The Method of Data Collection: Individual Interviews

To access the information, we used individual interviews with SMEs' managers in Marrakesh. Respondents express themselves according to the questions from the interview guide in order to drive the discussion through a series of previously defined themes.

Table 1. Data sources of the qualitative study (by authors)

Source	Who?	How?
Individual interviews Documentation	The managers of selected SMEs Selected SMEs	Audio recording Documents and Reports...

The Sampling Method

This method is the result of the balance between the objectives of the research and the level of theoretical saturation. By following these two criteria, it was impossible to know what would be the exact number of companies to be questioned.

It was therefore necessary to decrypt each individual interview in order to assess the importance of the information gathered in deciding whether to add additional interviews. We knew this when we proceeded to the decoding of the 11th and 12th interviews at which we noticed that the marginal information has such little value and interest; so, adding interviews are no longer justified.

ANALYSIS OF RESULTS

We used the content analysis to highlight tree key findings.

*According to all respondents, the business environment is characterized by a high degree of turbulence and unpredictability. This

degree differs from one sector of activity to another, depending on its structure, the number and size of competitors operating there, and the bargaining power of customers and suppliers.

The turbulence is due to changes in economy, technology and customer expectations at different scales.

Market, technology and competition are the most cited sources of turbulence emanating from the external environment. Regulation and social changes are seen as lesser factors of uncertainty.

But the importance and impact of each factor depends on the sector of activity.

The environment has become an important concept after considering the organization as an open system. We will retain the definition made by Pichault and Nizet (2001) where the environment of the organization constitutes a shifting set of information and resources (internal and external) or perceived as such by its members.

To understand them better, we must distinguish between external factors and internal factors. The first ones and according to Pichault and Nizet (2001), we should consider: the labor market and social regulation policy, the goods and services' market, cultural values and technology. Today, we need also to integrate sustainable development.

According to all respondents, the environment in which firms operate is a turbulent and unpredictable. They have to manage daily and urgent situations whose the origin is the environment with dynamic and disruptive phenomena.

We can say that the environmental constraint of SMEs presents several difficulties because of the constraint of identifying the relevant dimensions, the ambiguity characterizing the different conceptions, and the need to respond urgently to these changes.

* We have noticed that the choice of SMEs in view of the urgency of managing environmental constraints is subject to the influence of the manager's perception.

Bourgeois (1985) defends the subjective approach where the perception of the environment would be the key to the decision-making

process. Weick (1995) concluded that there are as many environments as there are businesses.

Each manager creates a structured form of the specific situation, which has a specific meaning and influences his choice. For this reason, the active research for information helps to reduce the uncertainty and the feeling of taking too much risk. Information on environmental factors is required by the company that wants to ovoid managing in urgency.

The perception of the environmental constraint is made through subjective judgments of the managers. The perceived environment depends on the information available and the ability to estimate the effects of this environment on the performance of the firm (Bourgeois, 1985).

For Silvestre and Goujet (1996), the nature of the environment depends on the capacity of managers to read it. Readability is considered as the ability to identify and understand the evolutions of the environment and it refers to the firm's information system.

The role of the manager is very important in SMEs to understand the environment. In fact, the manager's perception of the context is considered the relevant environment (Crozier and Friedberg, 2000). The SMEs' environment highlights a very important characteristic: the proximity.

According to Chappoz (1991), the SMEs' are known by the strong immersion in their environment. The lack of resources of SMEs encourages them to take advantage from opportunities and information that are nearby.

* We noticed that the manager's profile is paramount to environmental constraints. Decision-making process depends on how we understand, explain and represent the situation.

Managers, faced to the turbulent environment, are guided by their interpretations of reality (Lauriol, 1998). Managers construct a vision of the world on which they will act.

According to Cossette (2004), interpretation and action are inseparable and grow concurrently: representations of a problem will in some way determine how to solve it.

Based on the analysis of Weick (1995), we have identified a typology of managers in relationship to both: knowledge and action. Three profiles were identified:

- For the first profile, the knowledge and reflection direct action. In this case, the manager is more adept to plan.
- For the second profile, the action directs knowledge. In this case, the manager is more adept to improvise.
- For the third profile, the relationship is bidirectional. The manager can combine between planning and improvisation.

Through the analysis, we concluded that the environmental constraint is a source of urgency for the SMEs questioned. It is experienced differently by these companies and their managers. But, the observation is the same: the importance of the temporal pressure implied by the environment is growing and the importance of the consequences of these situations is also important. This importance is linked to the question of the firms' life.

The temporal axis, for the majority of the SMEs in this study, is characterized by the immediacy of the tasks to be accomplished, and governed by the microcosm effect (Mahé de Boislandelle, 1996).

The latter is the result of the focusing attention and energy of the manager on the immediacy. There are two distinct ways of considering this immediacy: the immediacy in time (the nearest term or the short term) and the immediacy in space (the closest psychologically or the relevant environment). Faced with this situation, the SME manager spends his energy focusing on proximity. This may involve the fact that it remains less vigilant and available to see and look further.

The microcosm effect would be that the small size often leads to a high frequency of events that can likely disrupt the decision-making process, expose the manager to daily disturbances and prevents him from spending time on strategic thinking or step back reasoning. Indeed, the more the manager spends his energy in proximity focus, the less he remains vigilant

and available to see and look outside the box and the less he will be predisposed to plan his actions.

The increasing of the microcosm effect and the overestimation of the present is due to the fact that the manager who thinks and focuses on the short term, suppose greater control over the consequences of his actions. Thus, he will be able to dominate its environment instead of being dominated by it.

Faced with the environmental constraints, managers do not have enough time to make a choice and study the different alternatives. The decision is defined as a risky choice between several alternatives and the implementation of the chosen solution (Amiel, Bonnet and Jacobs, 1998).

At the level of this research, we distinguished between the proactive decision and the reactive decision. The decision is proactive if it is based on the anticipation without any stimulus. The manager, in this case, makes a decision to avoid environmental constraints before they occur. Proactivity is defined by Senge (1990) as taking initiatives and moving beyond problems rather than undergoing them. It supposes, therefore, an act of anticipation. It is acting before the events taking place if not we should be dealt with them.

The reactive decision is taken in response to a stimulus. Reactivity is a defensive strategy to face emergency. It is not an intended strategy, but an imposed strategy by the urgency. As a result, there will be an inevitable alignment with environmental requirements.

The relationship between SMEs and the environment can be viewed from the point of view of dependence: “small businesses fit into a dense and complex environment. In most cases, it appears to be heavily influenced without exploiting its benefits” (Chappoz, 1991). A decision can be taken either to engage the future of the company or it is taken under duress. In the latter case, the manager makes the decision to accommodate the forces that go beyond him; this is a reactive or adaptive strategy. Here, the company tries to react quickly. The moment of the decision is therefore immediate and the resources of the company must be mobilized quickly.

CONCLUSION

According to the results of our research, the SMEs' managers, based on their companies' flexibility, seek adaptation to the environment. They implement rapid actions that can ensure the smooth running of the company. But SMEs can also implement proactive and innovative strategies. Indeed, some managers can anticipate, look for even fuzzy or ambiguous signals in order to interpret them very early and look for adequate answers.

In view of the emergency from the environment, SMEs may have the capacity for decision-making and action abroad the excessive determinism. Those actions seem to reveal the difference that may exist between the perceptions of emergency made by the managers and their profiles.

It seems to us that the decisions based on the reaction and of adaptation are in defensive logic. While proactive decisions tend to transform the current state. This is an offensive logic based on the attitude towards threatening signals that could create emergencies.

Through our research, we concluded that an SME strategy based on the ongoing search for responsiveness is a strategy imposed by the environment and not a strategy intended by the SME. A reactive strategy can't be desired by the company because it is dangerous and it can only be temporary (Gueguen, 2001).

The only responsiveness to the environment is dangerous because it reflects the weak position of SME faced to the constraints. It can't be considered as a fundamental objective of the company. The latter may seek to be reactive, but this can't be its sole purpose. Otherwise, it will be demobilized because of too reactionary and too oriented towards the short term. Similarly, the search for permanent reactivity implies an obligation to manage in real time what will weaken the firm's ability to anticipate and impose its own rules.

Reactivity can be seen as a good tactic (adaptability), but not as an ultimate goal and strategy for the company, because it condemns it not to think long term and to focus on consequences of the problems and not their origins. The company may be trapped in a spiral of reactivity.

According to Gueguen (2001), responsiveness leads to reactivity when the company implements adaptive measures and becomes unable to control its environment which evolves again and again. The company will still have to react and so on. It will suffer more and more, without changing the context.

To be a proactive company, time, is the most complex variable to understand why a company would be more proactive than another. Julien and Vaghely (2008) distinguish, in the context of anticipation and innovation, between long time and short time. Time affects both the time required to set up a good monitoring system and the capacities to absorb and transform the information gathered in decision-making.

The long time is one that focuses on developing the capacities of the manager and his organization to find, accumulate and interpret the information leading to the opportunities.

This time reflects the quality and diversity of human resources, the development of strategic intelligence, the training of catalysts and their integration in the information transformation of the organization and the choice or development of networks.

The short time, called by the two authors as the "right moment," affects the near environment in a striking way and thus requires synchronization between the operationalization and the receptivity of this environment.

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